MECHANICAL ENGINEERING

THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

IN THIS NUMBER

THE GERMAN DEFENSES ON THE COAST OF BELGIUM
By Lieut-Col. H. W. Miller, Ordnance Department
Artillery Division, U. S. A.

NATIONAL SCREW THREAD COMMISSION REPORT
Covering Standards for Threads and Thread Gages
Including Tolerances

JUNE 1920

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TABLE OF CONTENTS

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Special Features in Mechanical Engineering for June

The German Defenses on the Coast of Belgium, by Lieutenant-Colonel H. W. Miller, U.S.A., Artillery Division, Ordnance Department

The leading article in the June issue presents for the first time a detailed description of the German defenses on the coast of Belgium. These remarkable fortifications suffered but little from Allied shell fire and bombs, thus bringing forcibly to mind the fact that modern methods of construction can create coast defenses which are practically impregnable to attack from the sea. Colonel Miller was commissioned by the Government to report on the methods of gun design employed by the Germans, with particular reference to their policy regarding the standardization of gun parts and mechanisms. His paper describes in considerable detail the carriages, elevating and traversing mechanisms, etc., of the various batteries, and gives particulars regarding the fire-control stations, shelters, scope of service of the guns, etc.

National Screw Thread Commission Report

The National Screw Thread Commission, which has been at work since 1918 investigating and collating standards for screw threads, has just issued its report, an extended abstract of which appears in this number. The complete report covers 137 typewritten pages and contains 29 tables and 44 illustrations.

The National Screw Thread Commission is the first to have been appointed by Congress for standardization work. It is composed ot two representatives of the Army, two representatives of the Navy, and four civilians nominated by the engineering societies of America. Dr. S. W. Stratton, Director of the Bureau of Standards, is chairman.

The appointment of the Commission came about largely through the efforts of The American Society of Mechanical Engineers, the Society of Automotive Engineers, the Bureau of Standards, and prominent manufacturers of specialized thread products; and the work which the Commission has done is one of far-reaching importance and value.

The abstract covers standards for threads and thread gages, classification of fits, tolerances, gages, National (American) Pipe Threads, typical specifications for screw-thread products and future work of the Commission.

The Flow of Air Through Small Brass Tubes, by T. S. Taylor, Mellon Institute, University of Pittsburgh

The current number also contains a paper on The Flow of Air Through Small Brass Tubes, which presents the results of a study undertaken by the author in connection with his work on the general problem of ventilation. Mr. Taylor's paper, based on experiments, discusses the flow of air in brass tubes 3/8 in., 7/8 in., and 1 1/2 in. in diameter. He found that the velocity does not become constant until the air has passed through a length of about 200 cm. Tests made of the influence of oil and dust on the walls of the tubes are also described. These show that a small quantity of dust irregularly distributed greatly diminishes the air flow and produces a marked change in velocity distribution.

Industrial Housing—A Financial Problem, by Leslie H. Allen, Springfield, Mass.

The industrial housing problem is one confronting many manufacturers, for the expected fall in the price of building materials has not come, and speculative building seems to be definitely out of the field. Mr. Leslie H. Allen, of Springfield, Mass., discusses the problem in the current issue, treating it as a financial problem. He shows the relation of rents to capital invested and outlines the method of calculating proper rents and the financing of house construction. The financial difficulties which face those desiring to purchase new homes are also taken up and selling plans suggested. A new scheme of coöperative housing is also presented, which the author suggests may be the solution of America's housing problem.

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The German Defenses on the Coast of Belgium

A Description of the System of Fortification Employed, Together with Particulars Regarding the Guns, Fire-Control Stations, Shelters, etc., and Details of the Mechanisms of the Various Batteries

By Lt.-Col. H. W. Miller,[1] U. S. A.

On October 15, 1914, the Germans occupied Ostend and all of the Belgian coast north of that point. During the next few days their offensive gained for them the coast for a distance of about 10 miles farther south, including the city of Nieuport. It is understood from inhabitants of the city of Ostend that on the morning of October 15 the last boat loads of refugees left the harbor for England. The line of the farthest advance of the Germans in 1914 ran in a snake line south from the city of Nieuport, placing the cities of Dixmude, Polcappelle, and Ypres within the German lines. They were unable to hold all of their gains against the offensives of the Belgians and British during the next few months, and their line was pushed back to a point between Nieuport and Ostend, at Westende, about 8 miles south of Ostend. This line became a part of what has been known familiarly as the Hindenburg Line. From Westende line. Parts of the city are very old, dating back at least a half-dozen centuries. In this part of the town, which is mainly along the old harbor, the streets are narrow and characteristically crooked, the houses of quaint construction, and it does not require much imagination to make one believe that he has gotten back into the time of Columbus. It is understood that the old city of Ostend was heavily fortified and withstood several lengthy sieges. The last of these fortifications were removed in 1865, and only the slightest traces of them are still remaining. Other parts of the city are of quite recent construction and likely date from 1898, since which time considerable development has taken place. The streets in this section of the town are much wider, and straight, and the buildings of modern construction.

For many centuries Ostend figured prominently in the ocean trade between Belgium and the Indies and for a long period the

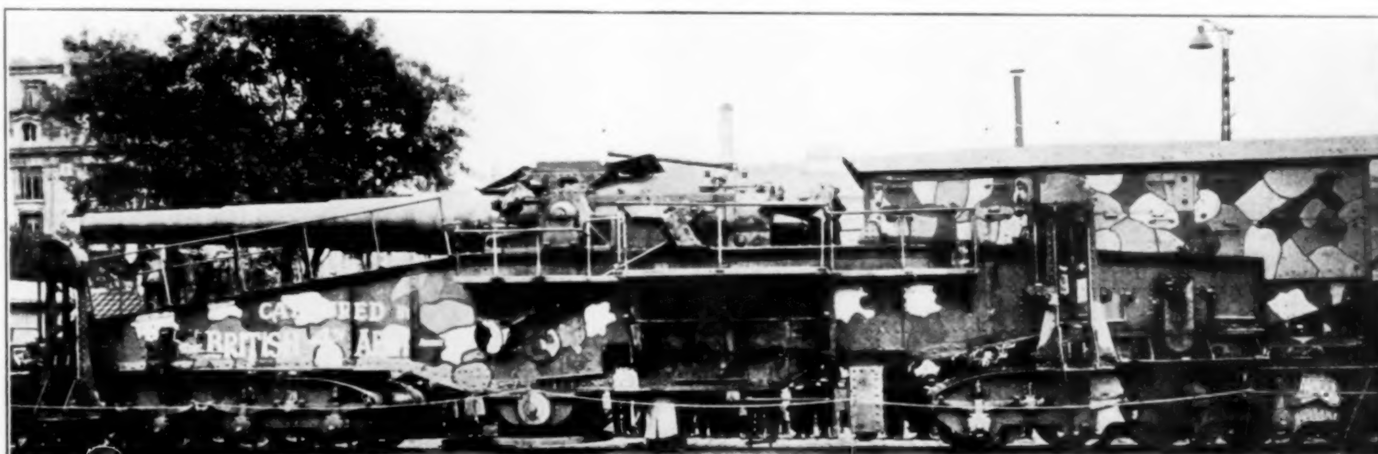

Fig. 1 German Railway Artillery Used for Coast Defense

it passed somewhat to the east of Nieuport and directly through Dixmude, about a mile to the east of Polcappelle, 5 miles to the east of Ypres, resting on what is known as Zonnebeck Ridge. This line was heavily fortified by the Germans, and their men were provided with adequate shelters. Even in the great offensives of 1918 this end of the line remained practically stationary. Four years after the original occupation, almost to a day, the Germans were driven out of Ostend, on October 17, and from Zeebrugge farther north, on the 18th.

Ostend, which figures as practically the center of these coast fortifications, numbered about forty thousand inhabitants at the beginning of the war. It is the second seaport in Belgium and stands about at the middle of Belgium's forty-two miles of coast

company known as the Ostend Company was very prominent in foreign shipping. The city is now equally prominent as a port and as practically the most attractive summer resort on the coast of France or Belgium. It is the home port of a large fleet of fishing vessels and the port of entry for a great part of Belgium's medium-tonnage ocean commerce. In 1900 work was begun on the harbor with a view to extending it back a distance of about two miles and providing a large basin and docking facilities for a considerable number of boats of medium tonnage. It is not known whether this program has been completed or not; apparently not, however, since the distance inland to the present locks is certainly not two miles. Extensive and heavy quays are provided all along the harbor for any boats that can negotiate the entrance. The quays nearest the entrance are the oldest and are now used almost entirely by the fishing boats, while the larger boats proceed farther up the harbor. The entrance to the harbor is quite narrow, being apparently not over two or three hundred

[1] Office of Chief of Ordnance, Artillery Division, Washington, D. C.
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feet in width. At the time of this inspection the hull of the British boat *Vindictive* was lying along and parallel to the northern side of the entrance, taking up about one-third of the space.

There is a promenade or "digue," constructed entirely of granite, on top of the dune in front of the city, which extends from the entrance to the harbor south for a distance of about two miles. The beach from a point near the entrance to the harbor for a considerable distance south is almost unsurpassed. There is a long line of fine summer hotels along the beach among which is

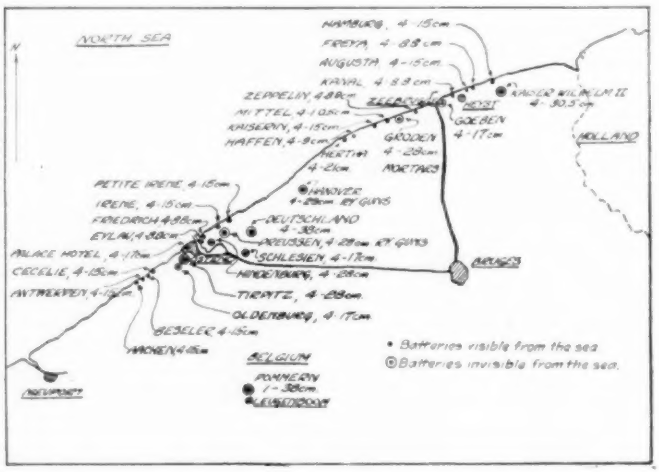

FIG. 2 PLAN OF GERMAN FORTIFICATIONS ON BELGIAN COAST

the famous Royal Palace Hotel, which has been very seriously damaged by the Germans, and in front of which one of the 17-cm. batteries and one of their fire-control stations was installed.

The Kursaal or Casino at the northern end of the principal bathing section of the beach was badly damaged by the Germans during their stay. The floors were removed, the windows knocked out, and the building generally damaged. Other portions of the city were badly damaged by bombs dropped from planes. The writer was told by the proprietor of the hotel at which he was staying that most of the damage seen about the town had been done by young German aviators who, returning from a fruitless bombing trip, usually released a few of their bombs on some prominent object in the city. The writer witnessed an interesting conference between a number of prominent citizens, at which plans were discussed for the awarding of some simple medal to those citizens who at considerable risk of their lives had rendered service in putting out fires started by these bombs and in rescuing wounded people from the damaged buildings. Those buildings which to all intents and purposes were intact had been almost completely robbed of their contents.

The locks leading from the head of the harbor into the canal to Bruges had been blown up, but whether by Allied air bombs or by the Germans on evacuating the area it is not known. They were being repaired in March 1919. An interesting bit of the Flemish language was seen on a sign at the end of a temporary foot bridge thrown across the locks. This sign read: "Est ist verboden te brugg over te gaan."

THE COAST AND COUNTRY

The coast of Belgium is low and sandy, and the slope of the shore is very gentle. Apparently there are only three points at which it is possible for ships to make an entrance, and it would be exceedingly difficult for even large rowboats to make a landing elsewhere, because of the fact that they would be grounded at a point several hundred yards beyond the shore line. All along the coast there is a sand dune which is about 50 ft. above the mean level of the ocean, and from 20 to 30 ft. above the average level of the land. This dune is not so pronounced below the city of Ostend as above. The Germans very systematically planted grass in these dunes in an attempt to prevent their shifting. It is quite probable that the sand gave them a great deal of difficulty in the maintenance of their artillery.

The land behind the dunes is comparatively level, so level, in fact, that it is inclined to be swampy in many places unless special care is taken in its drainage. In consequence, one finds drainage canals and ditches in all directions.

As previously mentioned, the Germans were very careful in building up fortifications along their line to provide concrete shelters for their men which made them comparatively comfortable and dry. It will be remembered that both armies paid considerable attention to the damming up of canals in the attempt to drown each other out, and there is a newspaper record of one case in which about 40,000 Germans were drowned. The accuracy of this statement, however, is doubted.

In March 1919 the canals and ditches about Nieuport were just being cleaned and repaired. Water was then flowing off some of the land that had been inundated for several years. In all directions platforms on stakes were visible in the grass, and in some cases board walks built on piles could be seen running for long distances. All sorts of platforms, shelters, etc., had been improvised. Usually where the line crossed roads, heavy concrete machine- and field-gun shelters had been constructed on both sides, these leaving spaces about 12 ft. broad in the middle, which were heavily barricaded with barbed wire. In numerous places the bones of both horses and men could be seen sticking out of the mud where they had fallen, and where it had been impossible to reach them and give them decent burial.

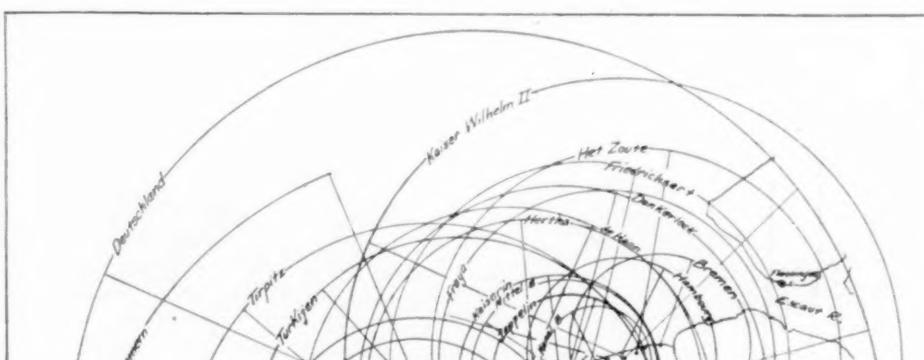

FIG. 3 RANGE CHART OF GERMAN FORTIFICATIONS ON BELGIAN COAST

Installation of the Fortifications

It is quite probable that shortly after their capture of Ostend and the occupation of the coast of Belgium, the Germans began the installation of small-caliber coast guns. It does not seem probable that they could have paid any particular attention to the installation of the extremely heavy guns at once, although they may have done so. As mentioned before, it is impossible for boats of any size to make a landing except at Zeebrugge and Ostend, and inasmuch as these two places had at first no particular value to the Germans, it is likely that they concluded that the Allies would not make any serious attempt to take them, since they would have to maintain considerable forces there and would have to use a considerable portion of their transport facilities in supplying them. When the German General Staff gave serious consideration to the plan for their major submarine campaign, it is probable that the harbors of Ostend and Zeebrugge loomed up prominently in their plans and that at once they set to work to fortify these two points with heavy guns.

The closest point on their own coast that could well be used as a base for submarines is Wilhelmshaven. They did not expect to operate their submarines to any great extent in the North Sea, hence there was nothing to be gained and a great deal to be lost by having their base so far from their scene of operations. The distance from Ostend to Wilhelmshaven is about 350 miles. With a base at Ostend for supplies and a well-protected point farther inland for minor repairs, they were saved a great deal of time and could more effectively annoy the Allies in the destruction of their shipping. The harbor of Ostend is ample for sheltering a fleet of submarines of whatever size, and it is connected by a canal with the city of Bruges, fourteen miles inland, where the submarines might be

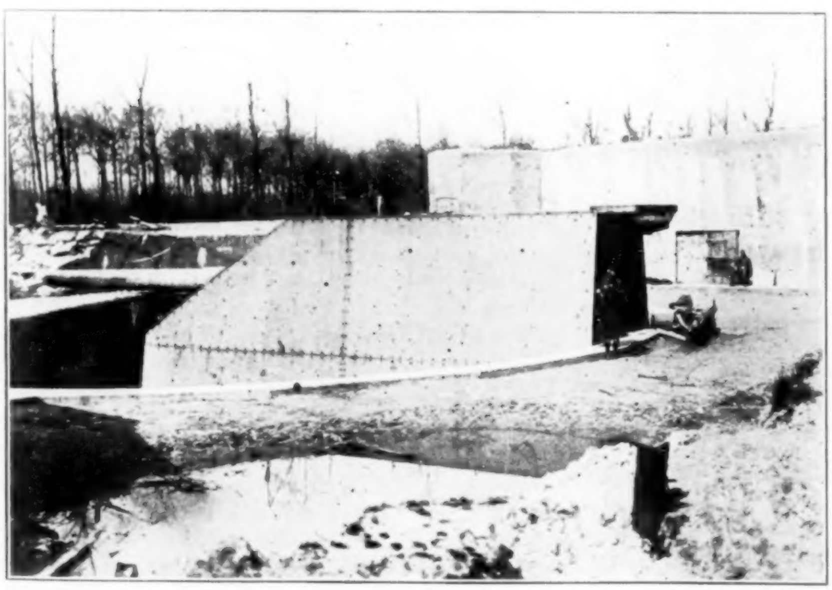

Fig. 4 Battery Pommern (380-mm. Gun) at Leugenboom, Belgium

repaired in the already existing basins. In recent years another canal has been constructed connecting the city of Bruges with the coast at the little village of Zeebrugge, fourteen miles north of Ostend. The village of Zeebrugge has no railroad facilities and there is no real harbor, boats entering there being lifted by the locks into the canal and proceeding to the docks at Bruges. It is probable that the submarines which required maintenance entered by Zeebrugge, since they could proceed more rapidly and easily inland than from Ostend. The extent of the repair facilities provided at Bruges is not known.

As soon as they decided to make use of the port of Ostend and the entrance at Zeebrugge, as well as the basins at Bruges for the supply and maintenance of their submarines, it became imperative that the Germans protect these two points against the raids the Allies might undertake in the attempt to bottle up the harbors or seriously damage the locks. To this end they started constructing the emplacements for their heavy guns at both points in 1915.

To the best of the writer's knowledge the installation of all the primary and secondary defenses, with the exception of those known as railway batteries, was complete in 1916. While the writer was with the British Fourth Army at Ypres in March 1918, he was told by the British Ordnance officers that they had received very authentic reports to the effect that the Germans were in-

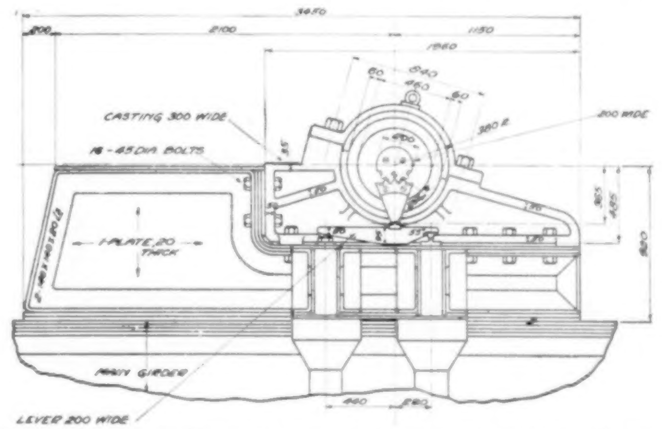

Fig. 5 Trunnion-Bearing Detail of German 380-mm. Mount, Battery Pommern

stalling railway batteries at various places along the coast. They had been given to understand that the guns for these railway batteries had been removed from the German Second Navy. The 28-cm. guns on railway mounts that were operated in the Batteries Preussen, Hannover and two other batteries not included on the map were probably some of these guns. The emplacements for three of these railway-mount batteries did not make their appearance in the air photographs until the spring of 1918.

Locations of the Armament

As a consequence of the practical impossibility of making any landing except at Zeebrugge and Ostend, no attempt was made to fortify the coast at other points. The heaviest of the fortifications were centered about Ostend, with others not much less effective about Zeebrugge. The primary armament, including the heaviest guns, was generally located at a distance of from two to five kilometers from the shore. The 38-cm. gun of the Battery Pommern at Leugenboom, the farthest point inland, was likely placed primarily for land service. This gun could operate against both Dunkirk and Ypres, and it did operate very extensively against the city of Dunkirk. It is probable, though not certain, that this gun took some part in the shelling of the city of Ypres when it was being reduced to ruins in 1915. The existence of this gun was well known to the men of the army about Ypres, with which the writer was associated for a time in March 1918.

The distribution and caliber of all of the 30 batteries on the coast is shown in Fig. 2. All of the batteries shown by dots were located on top of the dunes and were visible from the sea. Those batteries indicated by dots enclosed in rings were behind the dunes and had to depend upon the stations located in the dunes for their observation. The Palace Hotel Battery of 17-cm. guns was installed on the broad promenade just in front of the Royal Palace Hotel. This battery was particularly conspicuous. Battery Tirpitz just south of the city of Ostend was located in very swampy land, and it is understood that a great number of piles had to be driven to render the concrete emplacement stable. Considerable

FIG. 6 BATTERY DEUTSCHLAND
Note camouflage, wickerwork, and barbed-wire entanglements.

attention was paid to the draining of the region around this battery and Battery Oldenburg. All of the other inland batteries were installed on comparatively dry and solid ground.

Fire Control

Fire-control stations, particularly of those batteries located behind the dunes, were installed in the dunes on either side of Ostend and Zeebrugge. The stations for the batteries about Ostend were located, one on the promenade in front and to the north of the Royal Palace Hotel near the Palace Hotel Battery, and the other in the dune near the Battery Petite Irene. These stations are located in pairs and determine the position and range of a target by the method of triangulation. Specially devised rapid-operating plotting boards are provided to convert the readings of the observers into ranges and azimuths. Observations are made at regular intervals and the resulting data phoned from the plotting room to the various batteries which it controls. A third auxiliary station was found on the southern edge of the city. This probably was to be used in the event that the station in front of the Royal Palace Hotel, which was very conspicuous, might be damaged. This station was camouflaged as a house, having windows and doors painted on it. The men stationed in it observed the boats at sea through an 8-in. slit at the top. The stations located in the dunes were entirely covered with sand and it was practically impossible to see them from the sea. From some British officers in Ostend it was learned that the German batteries had been able to land heavy projectiles on the decks of some of their monitors at 40,000 yd. Somewhat similar feats are reported for the heavy guns of some of the German ships. This is exceptionally fine shooting and attempts were made to determine the methods of fire control employed in operating such ranges. No information to the writer's knowledge has been secured to date. The German ships as well as the fire-control rooms of the Belgian coast fortifications had been stripped of their fire-control apparatus before being surrendered or abandoned.

Shelter

In all of these fortifications the Germans fully lived up to their reputation for being strong on concrete shelters. Numerous such shelters for the men were found in the dunes and about the inland batteries. A partially constructed shelter was found just beside the locks at the upper end of the harbor of Ostend. If all the reinforcement which was exposed were covered with concrete, the roof of the shelter would be about 1.5 m. or 60 in. thick. According to their usual custom, several meters of earth would be placed on the top of this, making a very effective shelter.

Scope of Service

The range and scope of service of the various batteries is shown in Fig. 3. All of the guns, except the 38-cm. gun Pommern at Leugenboom, were capable of being traversed 360 deg. The range of 55 km. reported for the Battery Deutschland seems extreme. Various reports conflict in this respect, some crediting the batteries with a range of 42 km., some with a range of 47 km., and the last report, given in the *Bulletin Renseignements de l'Artillerie* of January and February 1919, with 55 km. The ranges given in Fig. 3 are in accordance with the report in the publication just mentioned.

Allied Attacks on Ostend and Zeebrugge

During the spring of 1918, April 23 to be exact, an attempt was made to block the harbors of Zeebrugge and Ostend. The mole at Zeebrugge was pierced and an obsolete cruiser, loaded with

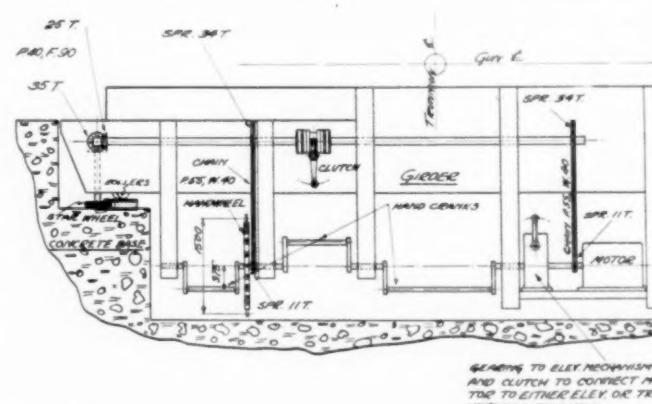

FIG. 7 TRAVERSING MECHANISM (ELEVATION) OF GERMAN 380-MM. MOUNT, BATTERY DEUTSCHLAND

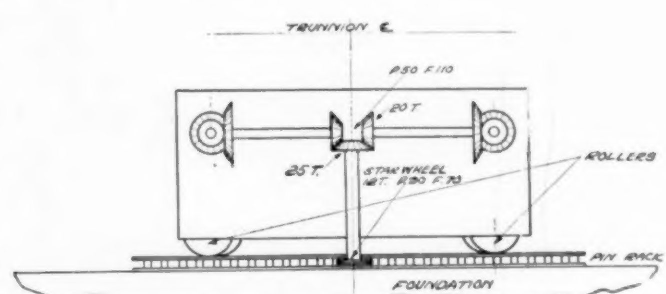

FIG. 8 TRAVERSING MECHANISM (REAR ELEVATION) OF GERMAN 380-MM. MOUNT, BATTERY DEUTSCHLAND

concrete, was placed across the entrance of Ostend harbor. The boats engaged in these undertakings received terrific punishment, but apparently accomplished their mission. It seems probable that had the Allies cared to make the sacrifice, it would have been possible to force either harbor, although it is not very likely that they could have retained possession of them for any great length of time. At the time of the inspection of these defenses, the writer observed the *Vindictive* still at the entrance to Ostend harbor. It had been raised and moved to a position as close as possible to and parallel with the north side of the entrance.

In the attack upon Zeebrugge the *Vindictive* was under the fire of a 150-mm. German gun at ranges of from 200 to 500 yd. for

approximately one hour. Portions of the superstructure of the boat were injured, but the *Vindictive* was not prevented from fulfilling its mission of landing a force of marines from two ferry boats which it had in tow. Certain facilities on the mole and in the harbor of Zeebrugge were destroyed and the mole was broken. This mole is simply a wall or breakwater extending into the ocean for a distance of about 100 yd. on the southern side of the entrance to the harbor.

Destruction from Shell Fire and Bombs

In spite of the fact that a majority of the batteries were located on top of the dunes and in plain sight of the sea, there is no evidence that any of them were damaged by shell fire. It is probable that no firing was done against the Palace Hotel Battery because of the damage that would be done the large buildings round about. It is understood on good authority that the Allied ships paid constant attention to both those batteries installed on the dunes, as well as those located behind the dunes. As early as 1916 the exact locations of practically every battery behind the dunes were determined from airplanes. Some of the pictures are shown in Figs. 12, 20, and 30. It is understood that the monitors came within a few kilometers of the coast at night, camouflaging their gun fire by blinding flares. It is reported that on practically all occasions when the ships shelled the coast fortifications during the day, heavy smoke screens were at once set up by the Germans which evidently afforded effective protection. Just back of the Battery Irene, between the dune and road, a large number of steel pots or cylinders 18 in. in diameter and 24 in. in height were found, which had been used by the Germans in setting up their smoke screens. The writer saw many of the holes made by airplane bombs and shown in Fig. 30, but could not find any single case in which either the inland guns or the guns in the dunes had been struck by shell firing from sea or by bombs dropped from airplanes.

The British monitors controlled some of their fire by the scheme of triangulation. Knowing that the Germans would at once set up a smoke screen between the batteries fired upon and the monitors firing, they were in the habit of placing one boat of inconspicuous construction a great distance off to serve as observer. This observing boat was so located as to be able to see behind the smoke screen. For firing on the heavier batteries behind the dunes, it was of course necessary to operate by indirect fire.

It is significant to note that when it became necessary for the Germans to evacuate this area in August 1918, the only artillery that they were able to get out was the railway artillery. From the inhabitants of Ostend it was learned that all of the batteries in that vicinity had been operated quite continuously against the Allied land forces for some days before the evacuation.

Final Destruction of the Batteries

Just before the area was evacuated, all the guns were destroyed with the exception of the 38-cm. gun at Leugenboom. One method seems to have been employed on the guns. In each case the rotating band was removed from one projectile, which was rammed into the bore of the gun; a second projectile was then rammed in and the gun fired. When the rear projectile struck the forward projectile it detonated, and in every case, except in the Battery Pommern as noted above, the breech of the gun was completely blown off and in most cases the carriage practically wrecked. In some cases the forward projectile likewise detonated, swelling or tearing off the muzzle of the gun; in other cases it was simply projected a short distance out of the gun. The guns and carriages after being wrecked were practically valueless, and no attempt was made to keep them in condition.

Purpose of the Investigation

Two investigations were made of these defenses. One of these was for the purpose of studying the tactical distribution of the entire armament. Until this war it has apparently been an undecided question as to whether any point on a coast or any section of a coast line can be so fortified as to be impregnable to attack from sea. During this war there were three sections of coast line that were so fortified as to be considered practically impregnable, except at a prohibitive cost, to attack from the sea. These were the section of German coast at Kiel, defended by mine fields and the fortifications at Heligoland; the Turkish center of Constantinople protected by the fortifications of the Strait of Gallipoli; and the Belgian coast protected by the fortifications of the only two landing points, Ostend and Zeebrugge. The disastrous attempt and failure to force the Straits of Gallipoli instilled in the Allies a wholesome respect for the difficulties involved there, and to the best of the writer's knowledge no real attempt was made to force the defenses of Heligoland and Kiel. It is probable that the defenses at Ostend could have been forced if the Allies had been willing to pay the price, but apparently they were not willing to do so. The investigation on the tactical distribution of this

FIG. 9 PEDESTAL AND PINTLE BEARING OF THE BATTERY DEUTSCHLAND

FIG. 10 380-MM. PROJECTILE AND SHOT TRUCK

latter armament was made by Majors Armstrong and Norton, Coast Artillery Corps, U. S. A., and their report was published in the *Journal of the U. S. Artillery* during the months of June, July, and August, 1919.

The second investigation was made by the writer for the purpose of determining whether the Germans had followed fixed policies in the designs of the various parts and mechanisms of their heavy guns and carriages, for example, cradles, carriages, armor, elevating and traversing mechanisms, etc., and for the purpose of making a detailed study of these parts and mechanisms. With ordnance designers of our own country and of the countries with which we have been associated in this war, there have been a number of questions on which there has been and still is some difference of opinion. Some believe that the cradles of heavy guns should be heavily braced by ribs, while others feel that there is no reason why they should not be simple smooth cylinders. Some designers are in favor of a front-pintle type of carriage

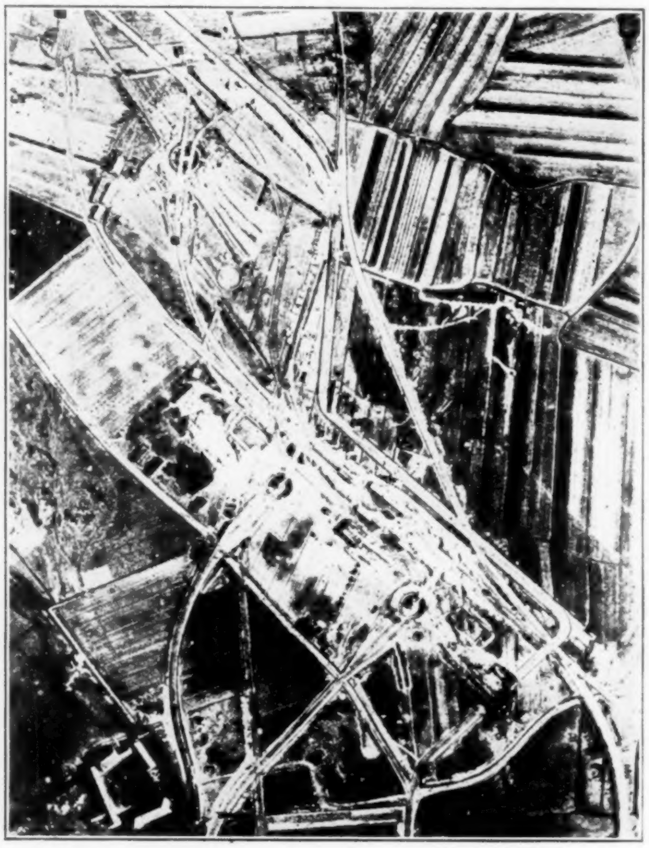

FIG. 11 BATTERY DEUTSCHLAND
Air photo taken August 9, 1916.

with simple friction bearings, or at best, roller bearings with racers of small diameter and more or less crude wheels or large rollers at the rear of the carriage on which it may be traversed. Others believe in a central-pintle type of carriage with large roller paths. It is seen at once that there is a vast difference in the difficulties involved in the manufacture of carriages designed under these different principles. Cradles with heavy ribs on the outside are difficult to cast and do not lend themselves to rapid manufacture. If smooth cylinders will answer just as well, it does not seem wise to hamper the manufacturers with the other design. Front-pintle carriages are in general easier to manufacture than the center-pintle type, hence unless there is something very vital to be gained in the central-pintle type of carriage with its large and difficult-to-manufacture roller paths, it would seem that the first design should have preference.

DETAILS OF THE MECHANISMS OF THE VARIOUS BATTERIES

BATTERY POMMERN

Gun. This battery, Fig. 4, consists of but one gun, Model 1914, Krupp No. 15 L. Its weight is 77,530 kg., overall length 17.13 m. and length from breech block to the muzzle 16.13 m., giving it an effective length of 42 calibers. It seems to be rated in some reports as a 45-caliber gun. This rating is evidently based on its overall length. There are 100 grooves, and the twist of the rifling is to the right 1 cm. in 10. The diameter of the powder chamber is 42.5 cm., and the outside diameter of the breech 1 m. The breech block is of the usual Krupp sliding-wedge type. The design of the gun is likewise identical with that of the 38-cm. guns of the Battery Deutschland, Fig. 6. In this figure it will be observed that the breech section has been blown away. The scheme of attaching the breech section by the interrupted-ring method is well shown. The recoil lug has a bearing at the bottom on the two sides of the recuperator cylinder for the purpose of preventing rotation of the gun.

Cradle. The cradle is a cylinder of simple design, having ribs at long intervals and a depth of only about 3 cm. The walls of the cylinder have a minimum thickness of 10 cm. and a maximum thickness of 13 cm. over the ribs. The diameter of the main trunnion, Fig. 5, is 46 cm. and the length 33.5 cm.; the diameter of the small trunnion 20 cm. and the length 19 cm. The anti-friction mechanism is of the rolling-wedge type. This cradle was provided with a counterweight identical with that shown on Fig. 6, and its front is so designed as to close the opening in the armor turret. Its total length is 3 m. and it is provided with brackets for the recoil and recuperator cylinders on the bottom. The cradle is lined with a bronze liner, approximately 6 mm. thick and 1 m. in length both at the front and rear. A portion of this liner may be seen in Fig. 6.

Recoil Mechanism. The two recoil cylinders are carried in brackets on either side of the center on the bottom, and the filling plugs are on the ends of the buffers. The recuperator cylinder is carried in the center in similar brackets and likewise has a filling plug on its forward end. Its rear end, which is planed on both sides, serves as a guide for the breech lug, to prevent rotation of the gun.

Elevating Mechanism. See the description of the elevating mechanism for the 38-cm. guns of the Battery Deutschland. The only difference between the two is that in this battery there is no provision for hand operation. The report found in the office of the Belgian Chief of Artillery stated that this gun had been originally provided for hand operation only, but that within the last year of the war it has been equipped with motors for electrical operation. The maximum elevation obtainable is 45 deg.

Traversing Mechanism. See the description of the traversing mechanism of the Battery Deutschland. There is provision for both hand and power operation of this mechanism. The wheel for hand operation, however, is located on the left of the carriage, very close to and on a level with the traversing rack. It is 1 m. in diameter. The maximum traverse provided for is about 157 deg. The center line of this field of fire passes approximately through Dunkirk.

Carriage. See the detailed description of the carriage for the 38-cm. guns of the Battery Deutschland. The only difference between these carriages is in the armor provided on the guns of the Battery Pommern. This will be described later under the heading of Protection.

Emplacement. The emplacement for this carriage is of exceed-

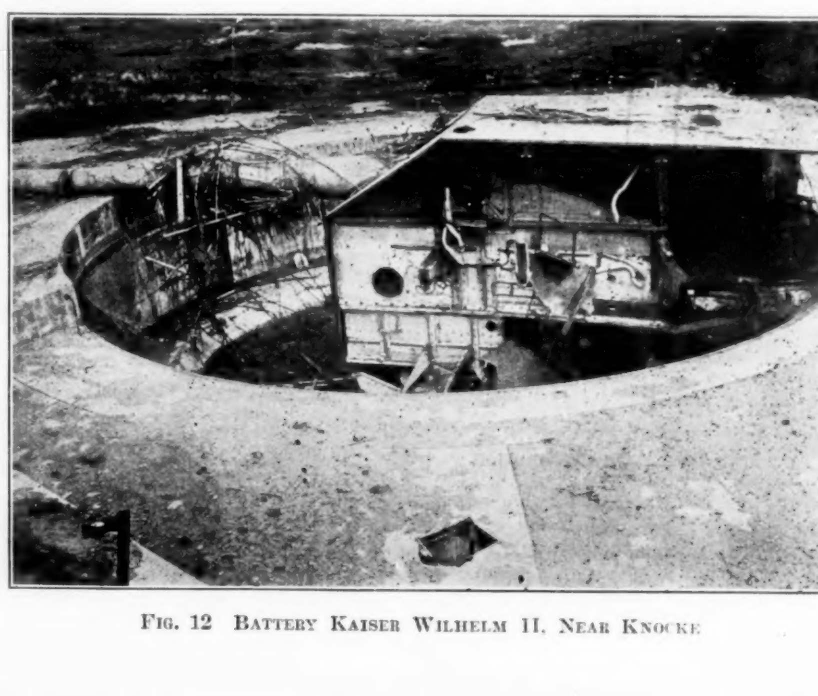

FIG. 12 BATTERY KAISER WILHELM II, NEAR KNOCKE

ingly massive concrete construction. The diameter of the central pit or well, in which the carriage is placed, is approximately 22.439 m. The form of the pit is not a complete circle, but is so shaped as to allow the carriage to be traversed 157 deg. The depth to the level of the traversing rack is 3 m. and the additional depth to the floor on which the center pintle rests 1.5 m., making a total depth of 4.5 m. On either side there are practically identical concrete structures, one of which is shown to the right in Fig. 4, for the housing of ammunition and personnel. One structure is for projectiles, the other for tools. Between these two structures at the front there is a concrete parapet 2 m. high and 3 m. thick. The earth slopes gradually away from the top of the parapet at the front, dropping about to the level of the main floor of the emplacement. The thickness of the roof of the structures is 3 m., the total height above the floor being 5.5 m.

Ammunition-Supply System. As just noted under the previous heading, the projectiles were stored in the concrete storehouse on the right and the powder in the storehouse on the left. Three weights of projectiles were used. The ammunition was supplied entirely by hand, shot trucks being used. The arrangement of the storehouse is in general, similar to that for the 305-mm. gun of the Battery Kaiser Wilhelm II. (See Fig. 19), the projectiles being piled two high. The report of the Belgian Chief of Artillery states that the projectiles were rammed by twelve men and that the rate of fire was 1 shot in 5 min. with electrical operation of the elevating mechanism, and 1 shot in 10 min. with hand

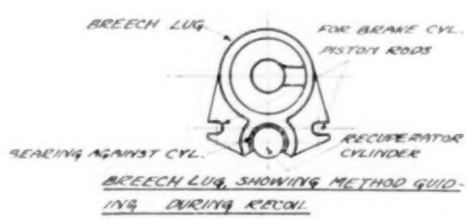

FIG. 13 BREECH LUG, SHOWING METHOD OF GUIDING DURING RECOIL, BATTERY KAISER WILHELM II

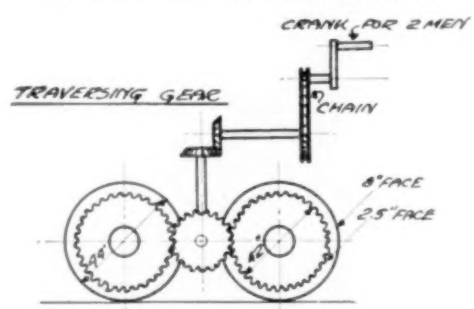

FIG. 14 TRAVERSING GEAR, BATTERY KAISER WILHELM II

operation of the elevating mechanism. The report further states that according to reports of people living at Leugenboom, the personnel originally provided for operation of the mount when it was operated by hand was one captain, two lieutenants, ten non-commissioned officers, and one hundred and sixty men. After provision was made for electrical operation of the various mechanisms, the personnel was reduced to one captain, two lieutenants, five or six non-commissioned officers, and seventy men.

The shells fired by the 38-cm. gun are as follows:

Name	Weight kg.	Fuse	Range km.
H. E. 38 cm. Sp. Gr. L/4.1 Bdz. with base fuse	750	Sp. Grn. K.	42
H. E. 38 cm. Sp. Gr. L/3.6 m. Bdz. (m Haube) with false ogive and base fuse	695	Sp. Grn. K.	
Do.; without false ogive	600		44
H. E. 38 cm. Sp. Gr. L/4 Bdz. A. Kz. (mHaube) with double fuse at head and base false ogive	342	Sp. Grm. K.	
Do,; Without false ogive			48

The charges are three in number:

1	Hutzenkartasch	Cartridge containing	87 kg.
2	Vorkartasche	Charge containing	96 kg.
3	Vorkartasche	Charge containing	118 kg.

It seems then that the gun can fire with two charges:

a 87 kg. + 118 kg. = 205 kg.

b 87 kg. + 118 kg. + 96 kg. = 301 kg.

Protection. To protect the personnel operating this gun against aircraft bombs and aircraft machine-gun fire, the carriage

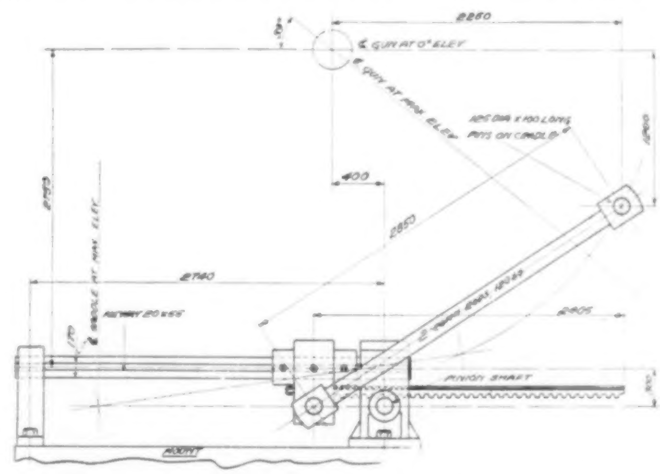

FIG. 15 ELEVATING MECHANISM (ELEVATION) OF GERMAN 305-MM. MOUNT, BATTERY KAISER WILHELM II

was covered with 6-cm. flat armor. This plating extends, to within a few centimeters of the floor of the pit. The hole in the front through which the gun projects, is sealed by the small shield on the front of the cradle.

Discussion. The parapet has been blown away in the center (See Fig. 4). There is evidence to indicate that the Germans used their characteristic method in attempting to destroy this

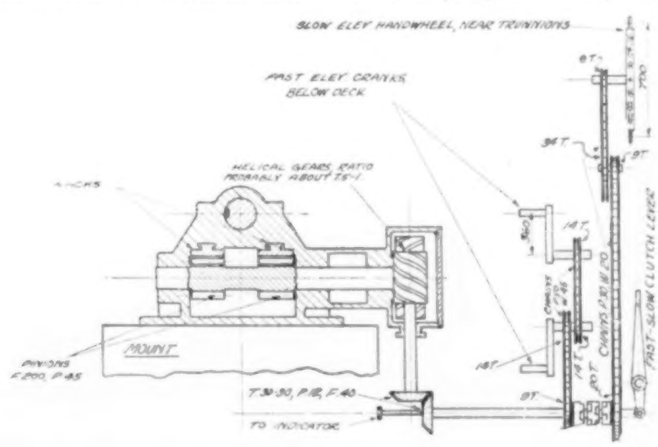

FIG. 16 ELEVATING MECHANISM (SECTION) OF GERMAN 305-MM. MOUNT, BATTERY KAISER WILHELM II

gun, but that in this case neither projectile detonated until they struck the parapet in front. Neither projectile could be found, hence it is assumed that both detonated. The gun was damaged only to a slight extent at the muzzle where some fragments of the projectiles were blown back into the bore, scoring it deeply.

BATTERY DEUTSCHLAND: 38-CM. GUNS

Gun. See the description of the 38-cm. gun of the Battery Pommern. The design of these four guns is identical with the design of the Model 1914 Krupp Gun, No. 15-L. The gun, Fig. 6, is Model 1916, No. 36-L. Its weight is given as 77,562 kg. This is Gun No. 4 of the battery; No. 3 is likewise a Model 1916, and numbered 35-L. Gun No. 2 is Model 1916, No. 41-L, and Gun No. 1 is Model 1914, No. 9-L.

Each of these guns had been destroyed by the characteristic German method of placing one projectile in the bore of the gun and firing another projectile into it. This procedure had resulted, in this case, in the blowing off of the entire breech and in the wrecking of the carriage. There was little evidence that any of these guns had been used to any great extent. The lands and grooves were in well-nigh perfect shape at least. It was evident that such damage as was visible had not been caused through ordinary fire. The width of the lands is 6 mm., and the depth of the grooves 3 mm.

Cradle. The cradle on each of these four guns is identical in design with that of the 38-cm. gun of the Battery Pommern. The counterweights on the Battery Pommern and Battery Deutschland cradles are identical. The one point of difference between the cradles of three of these guns and the cradle of the gun of the Battery Pommern is in the lack of any provision for the reduction of the friction of the trunnions. In Fig. 6 it will be observed that there are no auxiliary trunnions and no friction-reducing mechanism. There is no friction-reducing mechanism on Guns Nos. 2, 3,

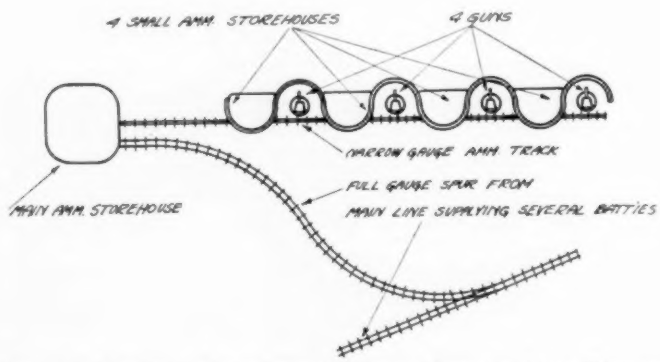

FIG. 17 TYPICAL AMMUNITION SUPPLY OF GERMAN COAST-DEFENSE BATTERY
Diagram of Battery Kaiser Wilhelm II.

and 4, but Gun No. 1 has one identical with that of Battery Pommern, Fig. 5. This omission of anti-friction devices on Guns Nos. 2, 3, and 4, which by the way are Model 1916 guns, can hardly be attributed to the lack of time for the installation, since the small amount of machine work necessary in the shop might have been handled without difficulty, and the work finished in the field if desired. Apparently they preferred to rely on a surplus of man power in elevating their guns.

Recoil Mechanism. The recoil mechanism is composed of two recoil cylinders and one spring pneumatic recuperator cylinder, all located at the bottom of the cradle. It is identical in design with the recoil mechanism of the Battery Pommern gun.

Elevating Mechanism. The elevating mechanism on each of these guns, as well as on the 38-cm. gun of the Battery Pommern, is composed of two large telescoping screws, the larger screw passing through a nut carried in an oscillating bearing at the bottom of the carriage. The larger of the elevating screws can be seen about in line with one of the elevating and traversing handles at the bottom of the carriage in Fig. 6. The larger of these two screws is about 37 cm. in diameter and the smaller about 20 cm. The large nut in the oscillating bearing is driven through cross-shafts either by the motor or by the hand mechanism which is used likewise for the traversing mechanism.

The maximum elevation at which the gun is operated is not known. There were no elevating arcs remaining on any of the cradles that would indicate to what extent they could be elevated. It is assumed, however, that the maximum elevation obtainable is the same as that in the Battery Pommern gun, which is 45 deg. The box just to the rear of the camouflage near the bottom of the carriage, Fig. 6, is the housing for the clutch connecting the elevating mechanism with either the motor or the hand drive. All of this mechanism is duplicated on the left side of the carriage. The motor driving the elevating and traversing mechanisms is on the same platform as the transmission box, but, as will be seen, it is practically hidden by the wire camouflage which has fallen.

Traversing Mechanism. The various details of the traversing mechanism are shown in Figs. 7 and 8. Provision is made for its operation by hand as well as by motor. This hand mechanism is operated by eight men.

The rear of the carriage is supported on two heavy rollers 96 cm. in diameter by 23 cm. on the face which are carried on 21-cm. spindles. A complete circular steel bearing plate is bolted to the first shelf of the pit. This plate is 12 cm. thick by 1 m. in width, and a traversing arc made of three angles and a series of 5-cm. steel pins is bolted to its outer edge. The star traversing pinion, 21 cm. outside diameter, meshes with this rack and is driven by either the motor or the hand mechanism. The radius to the center of the traversing rack pins is 10.439 m.

Carriage. The carriage is entirely of structural steel (see Fig. 6). It is of the front-pintle type, the front being carried on steel balls. The ball path is 2 m. in diameter and the balls, which are separated by a bronze distance ring, are 15 cm. in diameter. The pintle, which is not much less than 2 m. in diameter, is a part of the base ring which is bolted to the top of the pedestal, Fig. 9. The pintle projects into the racer a distance of about 12 cm. with which it comes into direct contact on firing, thereby transmitting the horizontal component of the shock of recoil into the pedestal and concrete base. As noted under Traversing Mechanism, the rear of the carriage is supported on two rollers 96 cm. in diameter. These rollers have a face of 23 cm. and are carried on steel spindles 21 cm. in diameter. The distance between the centers of these spindles is approximately 3.3 m. The rollers appeared to be perfectly cylindrical, with rounded edges. The construction of this carriage for one of their heaviest guns is exceedingly simple. The only heavy castings are those for the pedestal, the base ring, the elevating oscillating bearing, and the trunnion bearing. The only parts of the entire mechanism which obviously require fine machine work are the trunnion bearings, the heavy steel balls, and the ball paths.

Emplacement. With the omission of the heavy concrete struc-

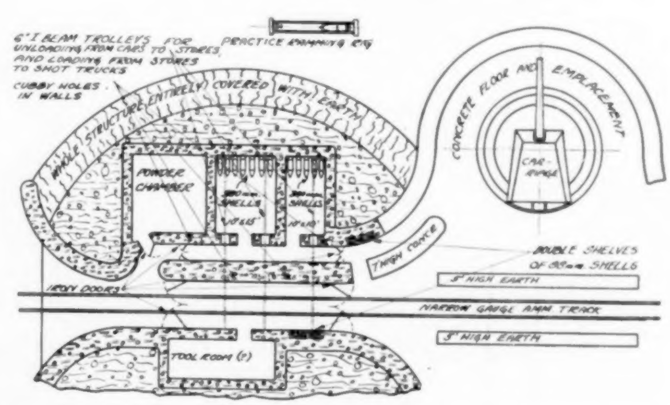

FIG. 18 TYPICAL AMMUNITION STORES SYSTEM FOR GERMAN COAST-DEFENSE GUN
Plan of one gun in Battery Kaiser Wilhelm II. Section through storehouse cut about 8 ft. above ground.

tures described under Battery Pommern for ammunition and personnel, the emplacements for the Batteries Pommern and Deutschland are nearly identical. Battery Pommern was finally fitted up for electrical operation only, and most of the mechanism for hand operation is removed. In the lower part of the Battery Deutschland pit a wood floor made up in sectors raised the floor to such an extent that the men operating the traversing and elevating mechanisms would be on the proper level. The pit was filled with water at the time of the inspection to such an extent that these sectors had come loose and were floating. The emplacement provided for 360 deg. traverse of the carriage as against 157 deg. for the Battery Pommern.

Ammunition-Supply System. See the description of the ammunition-supply system for the Battery Pommern. There was no evidence of any provision for any mechanical handling of the

projectiles except in the lifting of them from the floor to the storehouse and placing them on the shot trucks. Between Guns Nos. 2 and 3 of this battery there was found a practice shell-ramming tray. This tray comprises a steel trough about 10 ft. long with an ordinary railway-car buffer at the end. A shot truck carrying a projectile with a false ogive is shown in Fig. 10.

Protection. It is significant to note with reference to the three of the newest of these guns, that is, Nos. 2, 3, and 4, that there was absolutely no protection provided either for the gun carriage or personnel. Evidence of their scheme of camouflage can still be seen in Fig. 11. This camouflage was unable to hide the guns from the air photographers, as this photograph (Fig. 11), taken on August 9, 1916, shows the emplacements quite plainly. In spite of this fact there was no evidence to show that any of the guns or emplacements had ever been damaged either by shell fire from sea or by bombs from the air. Several holes that had been made either by bombs or by shells were visible in the fields in front of the guns. Gun No. 1 was protected with 6-cm. armor in the same fashion as the gun of Battery Pommern. Gun No. 1 of this battery and the 38-cm. gun of the Battery Pommern are identical in design throughout. Both are Model 1914 guns, and it is probable that the hand elevating and traversing mechanisms of the Pommern gun were identical with those of the Deutschland guns before the electrical equipment was provided.

Discussion. Significant points with reference to this battery are that guns Nos. 2, 3, and 4 are not provided with either trunnion anti-friction devices or positive protection in the form of steel armor.

Battery Kaiser Wilhelm II: 305-mm. Gun

Gun. With each of these four guns, Fig. 12, the scheme of destruction was so effective that it was impossible to find a breech after a half-day's search. It is assumed that they were of a model at least as late as 1916. The ***Bulletin de Renseignements de l'Artillerie*** states that they were 50 calibers in length. One breech block found later was of the usual Krupp sliding-wedge type. The guns are rifled with 88 grooves and the twist of the rifling is to the right 1 cm. in 10. Projectiles found in the storehouse had two rotating bands, from which it may be assumed that the pitch of the rifling is uniform.

Cradle. The cradles for all of these guns are smooth cylinders, the walls of which are 10 cm. thick. The brackets at the bottom of the cradle provided for the recoil and recuperator cylinders are quite similar to those of the 38-cm. gun. The front of the cradle is provided with a shield (see Fig. 12), which closes the opening in the armor. The cradle is likewise provided with a heavy counterweight, which can also be seen in Fig. 12. The anti-friction device is of the rolling-wedge type. It is significant that in this case the auxiliary trunnion is but slightly less in diameter than the main trunnion. In practically all other cases observed, the diameter of the small trunnion was approximately one-half of the diameter of the large trunnion.

Recoil Mechanism. The recoil mechanism for this gun is in general a duplicate of that for the 38-cm. gun. The breech lug, with the method of attaching the recoil pistons, and the bearing of the lug on the recuperator cylinder to prevent rotation of the gun, are shown in Fig. 13. In contrast to the 38-cm. gun, in which the recoil pistons pass through holes in the recoil lug and the recoil lug bears on two planed sides of the recuperator cylinder, it will be observed in this case that the lug is slotted on the sides to receive the recoil pistons, and the bearing on the recuperator cylinder is circular instead of flat.

The outside diameter of the recoil cylinder is 38 cm. and the length is 1.68 m. The diameter of the piston is 15 cm. and the length of recoil 1.37 m. These cylinders are both smooth forgings, with flanges at the front bearing against the cast bracket on the cradle. There was no evidence of a counter-recoil buffer. On the front end of the cylinders there are filling plugs similar to those found on the 38-cm. cradles. The single recuperator cylinder is likewise a smooth forging, with one large flange on its forward end. It is of the combined air-spring type and is approximately 45.6 cm. in diameter by 4.25 m. in length. This cylinder likewise has a filling plug at the front end.

Elevating Mechanism. The elevating mechanism for these guns is in principle the same as that for the 38-cm. railway mount. The designs of its details, shown in Figs. 15 and 16, are, however, quite different. Apparently it was operated entirely by hand. There are two two-man handles below the deck of the carriage for rapid elevation, and above the deck a single handwheel of large diameter for final and careful setting. The clutch for shifting from the low gear to the high is located below deck. Motion is transmitted from the handwheels to the horizontal shaft at the bottom and through the bevel and helical gears to the two pinions on the main horizontal elevating shaft. The two straight racks, which in this case are horizontal, are connected to the crosshead, which slides on a single round shaft as a guide (see Fig. 13). This crosshead in turn transmits motion to the gun through the two connecting rods. The two racks have guides on the top, which slide in ways in the forward support of the main horizontal guide shaft (see Fig. 16). It was not possible to elevate the

Fig. 19 Battery Kaiser Wilhelm II
Air photo taken August 9, 1916.

gun, and the ratio of the gearing is not known. This mechanism, together with its companion mechanism on the 38-cm. railway mount, is quite unique among the mechanisms observed on all German artillery. The reasons for the design seen on the railway mount seem obvious, but the same reasons do not hold on this carriage. Certainly a simpler mechanism of equal efficiency could have been provided. The maximum elevation obtainable is 45 deg.

Traversing Mechanism. The traversing mechanism, Fig. 16, is operated both by hand and motor. The roller track is set in the concrete emplacement. In this case, contrary to the design of the same mechanism for the Batteries Pommern and Deutschland, there is no traversing rack provided in connection with the roller track. Motion is transmitted through chains and gears from the motor or handwheel to the traversing pinion, which meshes with the two gears bolted to the faces of the traversing rollers. The simplicity of this mechanism is very striking, especially for

guns of this size. Apparently it worked satisfactorily, or it would not have been retained in a gun of such value. It is certainly worthy of serious consideration for similar carriages for our own service. An azimuth circle is embedded in the vertical walls of the concrete emplacement about two feet from the top. An indicator is provided on the rear of the carriage with a vertical wire quite close to this azimuth circle. The switchboard and seat for the traversing operator are located beside this indicator.

Carriage. The carriages are constructed entirely of structural steel. The side girders are in three main sections comprising a central section of uniform depth, a top brace for the trunnion support, and a bottom section for the pintle. The pintle bearing is of the ball type, the balls being about 15 cm. in diameter. In this case the racer serves as a pintle, having a positive bearing against the base ring for the transmission of the horizontal component of the force of recoil into the foundation.

Ammunition-Supply System. The general plan of the Battery Kaiser Wilhelm II is shown in Fig. 17. Storehouses are located on the left of each gun and the main storehouse is 100 m. to the left of the battery. The narrow-gage line, shown extending from the main storehouse, passes through each auxiliary storehouse. A typical plan of one gun and its storehouse is given in Fig. 18. The double narrow-gage lines shown passing through the storehouse are the same as those shown in Fig. 17. These storehouses are of excellent construction and are typical of the design of the storehouses for most of the heavy batteries inspected. The plan for the Battery Deutschland is almost identical. The external plan for the Battery Pommern is slightly different, but the interior arrangement is well nigh the same.

Projectiles are transported from the main storehouse to the individual storehouses on narrow-gage railway trucks. From these trucks they are carried by means of an overhead trolley through openings in the walls into the projectile rooms, where they are stacked two high. Later they are picked up and carried by the same trolley into the corridor just outside the shell room and placed on the shot trucks. The table of this truck is quite broad and the shell is placed on one side, where it is held by two arms until it is to be rammed. The truck is provided with a shelf, presumably for powder. There was no evidence of any scheme of handling the ammunition except by hand. The rammer found beside one of the guns is of such a length as to indicate that the projectile was probably rammed by eight men. The guns are loaded at zero elevation. Another practice shell-ramming tray was found beside one of the emplacements.

Emplacement. The design of the emplacement for these guns is shown in Fig. 12. It will be observed that all the space about the gun leading to the ammunition storehouse is floored with concrete. In this respect the emplacement differs from that of the Battery Deutschland, in which the concrete work did not extend much beyond the vertical walls of the pit. It is not known just why the walls of the pit are higher in front than in the rear, as there seems to be no particular reason for it. The depth of the pit to the roller path is 2.4 m., and the total depth 3.6 m.

Protection. Each of the four guns of this battery is protected with 6-cm. flat armor. The guns and carriages were likewise elaborately camouflaged to hide them from the sight of the airmen, but air photographs taken on August 9, 1916, one of which is reproduced in Fig. 19, indicate that it was perfectly possible to see the emplacements. In spite of this there was no evidence that any of these guns, carriages, or emplacements had ever been damaged by shell fire from sea or by bombs from airplanes. Some holes were visible some distance in front of the emplacements, which may have been made by either bombs or shells. A few similar shell holes were visible some distance to the rear.

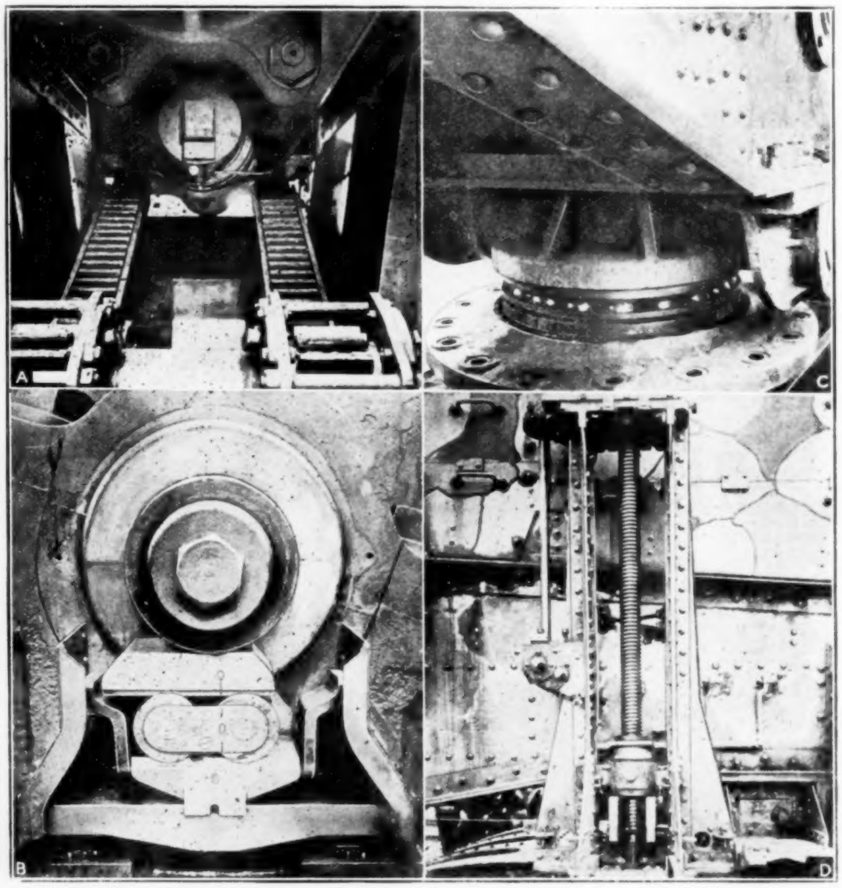

FIG. 20 DETAILS OF THE 280-MM. GERMAN RAILWAY MOUNT
A Elevating Racks
B Trunnion Anti-Friction Mechanism
C Base, Ball Bearing and Swiveled Racer
D Emplacing Jack

BATTERY PREUSSEN: 28-CM. GUN RAILWAY MOUNT

Gun. The gun on the mount examined (see Fig. 1) is a 40-caliber naval piece of Model 1914 of 42 calibers total length. The tube is rifled with 80 grooves having a uniform twist to the right of 1 cm. in 10. The breech block is of the ordinary Krupp sliding-wedge type and is fitted with a mechanical firing mechanism. As with all other large guns having this type of breech, this gun uses semi-fixed ammunition.

Recoil Mechanism. The recoil mechanism is of the hydro-pneumatic type, and comprises one pneumatic recuperator cylinder mounted at the bottom of the cradle in the center and two hydraulic cylinders likewise mounted on the bottom of the cradle and on either side of the recuperator cylinder.

Elevating Mechanism. The elevating mechanism, shown in Fig. 20-A, comprises two straight racks engaging with two pinions enclosed in floating housings and attached to one shaft. This shaft is connected by means of a worm, wheel and shaft, and on the right side of the gun with elevating handwheel shown near the elevation quadrant. This is the only railway mount so far observed in any of the armies in which the attempt has been made to use this straight rack, which is much more easily machined than any of the usual curved elevating racks. On the under side of the floating housings two rollers are carried on which the back of the rack rides and which hold the rack in perfect mesh with the pinions. These two racks are attached by means of heavy pins to the rear of a cradle. The cradle trunnions are provided with an anti-friction device of the type shown in Fig. 20-B.

Traversing Mechanism. Two traversing mechanisms are pro-

vided on the mounts used in these batteries. The one is provided to permit the mount to be fired from its wheels on a standard track. This mechanism permits the car body to be rotated about the pintle or kingpin of the front truck, and affords a total traverse of 2 deg., that is, 1 deg. on each side of the center line. The other mechanism permits the mount to be rotated about a central pivot attached to the car body. This mechanism affords 360 deg. traverse and is the only one with which we are concerned in the use of the mount for coast defense. It comprises a center pivot and two rear support rollers. The center pivot, Fig. 20-C, comprises a base 1.78 m. in diameter which bolts to the ground platform by 20.6-cm. bolts. This base contains a pintle about which the mount rotates and supports a ball bearing with sixteen 15-cm. balls on which the swiveled racer carrying the mount rests. The racer is carried by means of its trunnions in steel bearings bolted to the bottoms of the side trunnions. Thus the car body can swivel in a vertical plane as well as rotate in a horizontal plane about the base. The rear end of the mount is supported on a track in the foundation by two rollers 60 cm. in diameter by 10 cm. on the face, the housing of which is bolted to the side girders. These rollers are set on a radius of 4.5 m. from the center pivot. To the face of each roller a spur gear is bolted. A single pinion placed between these spur gears and meshing with both of them is driven from the hand mechanism on the side of the mount. Twenty-four turns of the handle give one revolution of the roller. An azimuth circle was found painted on the steel roller track. It seems unlikely, however, that this was ever used except for approximate settings of the mount, for without much doubt the mount was laid exactly in azimuth by means of a panoramic sight and an aiming point.

Gun Carriage. The gun is carried in a cradle of simple cylindrical design, which is supported by means of its trunnions in bearings attached to the side girders of the car body. The cradle is provided with a heavy counterweight just above the trunnions to raise the center of gravity of the tipping parts sufficiently to permit easy elevating and depressing. Each of the trunnions is provided with an anti-friction device of the design shown in Fig. 20-B. The car body is built up of two single-web structural-steel side girders carried by a series of structural-steel transoms and deck plates, and the car platform is covered with light armor. Both the traversing roller housing and center pinion bearings are bolted to the bottom of the side girders and serve to stiffen it. Jacking beams, which in the case of the mount examined had the jacks attached (see Fig. 1), are carried under the forward and rear ends of the car body. The car-traversing mechanism forms a part of the upper center plate of the rear truck.

FIG. 21 EMPLACEMENT OF BATTERY PREUSSEN

Emplacement. The construction of the emplacement, which is typical of the 16 emplacements found along the coast, is shown in Fig. 21. The two short sections of rail are carried by a steel plate which rests on top of the base for support as the mount passes over. This steel plate was blown off when the Germans were demolishing the emplacement. The standard-gage track extends a short distance beyond the emplacement to receive the forward truck when removed from the mount. The mount is run into place with the emplacement arranged in general, as shown in Fig. 21. The small sections of track of the center are then removed in order that the pivot may be lowered on to the structural base by means of the lowering screw and bolted fast by 21 bolts. Four special jacks of the design shown on Fig. 20-D and attached to the jacking beams located under the front and

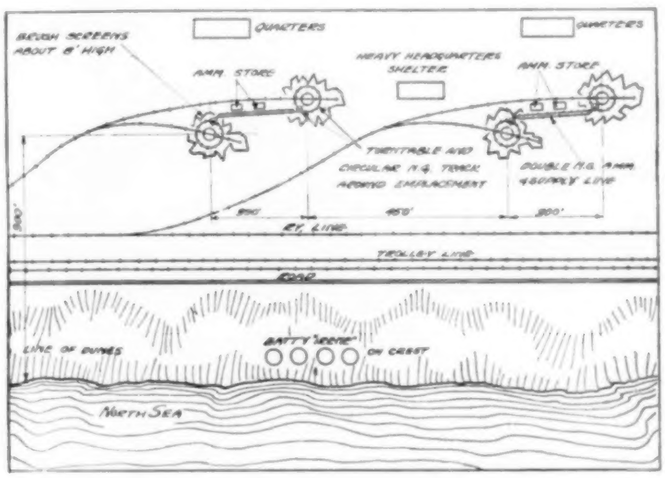

FIG. 22 PLAN OF BATTERY PREUSSEN (28-CM. RAILWAY GUNS)

rear of the mount are then laid down and the mount is raised by them sufficiently to permit the trucks to be removed, as well as the two sections of track connecting the center with the rim of the emplacement. The entire mount is then lowered until the rear rests upon the central track by means of the rollers, and the forward end rests on the 16 steel balls in the central pivot.

The general location of the emplacement of this battery with reference to the main railway line on which the mounts were brought in, and likewise with reference to the coast line, is shown in Fig. 22. Two spur lines are run in from the main line. It is not quite clear why this was done. It would obviously have been possible to run short lines to the two guns on the left from the spur line in the center, which line, as will be seen from the figure, has been used only for the two guns on the right.

Ammunition-Supply System. The location of the ammunition storehouses and the narrow-gage connections with the emplacements is shown in Fig. 22. In each case the standard-gage line runs at the rear of the simple concrete storage houses which are provided with two doors both at the front and rear. The powder is kept in the one storehouse and the shells in the other. The double line of 30-cm. track connects the storehouses with the two emplacements. These narrow-gage lines connect with a turntable just inside the wicker protection. A complete circle of narrow-gage track is provided about each emplacement, making it possible to supply shells to the mount in any position. There was no evidence of any scheme of storing the projectiles or powder closer to the mount than the storehouses. Evidently a sufficient number of shot trucks are provided for these narrow-gage lines so that the shells can be provided directly from the storehouses at the maximum

Fig. 23 Battery Tirpitz, Near Ostend

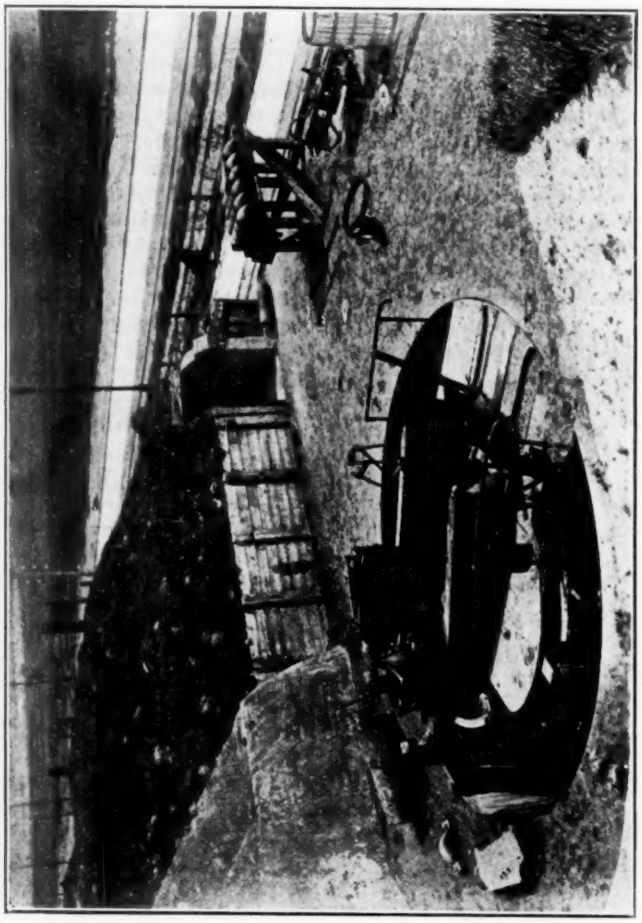

Fig. 24 Battery Groden (280-mm. Mortars)

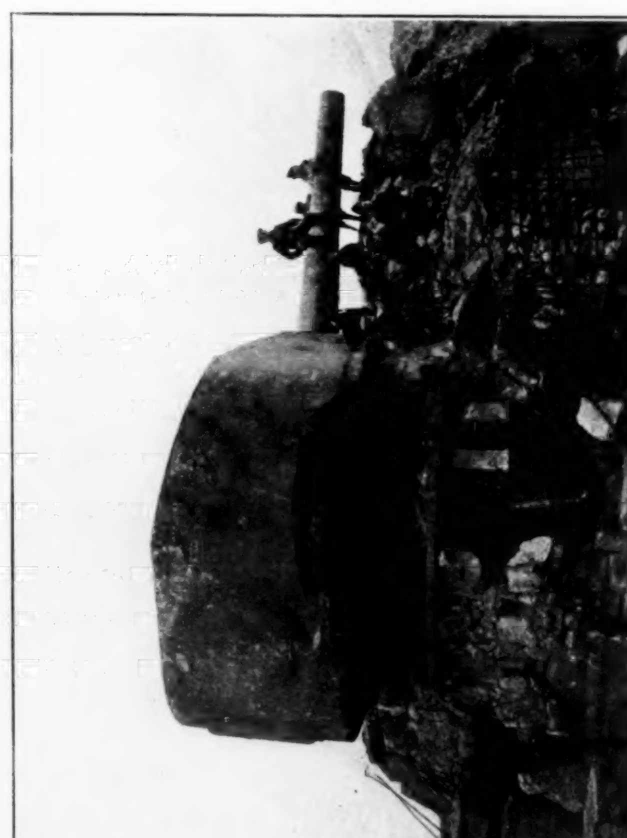

Fig. 25 Battery Goeben (170-mm. Guns) at Zeebrugge

Fig. 26 Battery Irene (150-mm. Guns)
Note stranded German submarine.

firing rate of the gun. The ammunition storehouses are well camouflaged, but in spite of this, air photographs taken in 1918 clearly indicate the positions of the guns as well as the storehouses.

Protection. The gun crew was protected to a certain extent by the light metal cab on the mount. The mounts were likewise screened with wire and brush, the remains of which can be seen in Fig. 21. In spite of this camouflage, air photographs showed quite clearly the position of the emplacements. There was no evidence of damage from shell fire or air bombs on the emplacements or storehouses. A heavy concrete earth-covered headquarters shelter with telephone connections from the observation stations in the dunes and telephone connections to the various guns was provided between the pairs of guns. In the case of each emplacement there is a cable through the central pintle base which evidently carries the telephone connections between headquarters and the mount.

Battery Tirpitz: 28-Cm. Gun

Gun. Battery Tirpitz is a four-gun battery, and all of the guns are of Model 1911. The gun of the four which was examined in detail, shown in Fig. 23, is Model 1911, No. 5. Its weight is 33,875 kg. The length of the tube from the face of the breech block to the muzzle is 11.220 m., and the overall length of the gun is 11.950 m. There are 80 grooves, and the twist of the rifling is to the right 1 cm. in 10. The diameter of the powder chamber is 30 cm. The breech is of the usual Krupp sliding-wedge type. As with the 38-cm. gun found on the railway mount, the tube of this gun has lengthened from firing, thereby separating the forward hoop a noticeable distance from the hoop to the rear. Apparently these hoops are not locked to each other. The lower extension of the breech lug is machined to bear against the planed inner surfaces of the lower recuperator cylinders, thereby preventing rotation of the gun. The gun does not show signs of very great wear, both the lands and the grooves being quite sharp.

Cradle. The cradle is a smooth cylinder with walls 10 cm. thick and is lined with bronze liners about 6 mm. thick by 1 m. in length at both the forward and rear ends. The trunnions are located noticeably close to the forward end. The anti-friction device is of the rolling-wedge type. There were no unusual features in this design, and no sketch has been made.

Recoil Mechanism. The recoil mechanism comprises two recoil cylinders located on the top and bottom of the cradle and four recuperator cylinders. The two recoil cylinders are smooth forgings carried in the cast brackets on the top and bottom of the cradle. Their length, not including the buffer, is 1.22 m., and the length of the buffer is 24 cm. The piston rods, 11.5 cm. in diameter, pass through holes in the extensions of the breech lug. The length of recoil is approximately 76 cm. The four recuperator cylinders are placed symmetrically above and below; the upper cylinders are combined spring and air recuperators, while the lower are spring only. A common air line is connected to the valves on the forward ends of the upper two cylinders. It is believed that the air is supplied from bottles since there was no evidence of an air pump about the carriage. Both above and below, two rods connect the extensions of the breech lug with the crossheads attached to the piston rods of the recuperator cylinders. These rods taper from 4 cm. at the crossheads to 5 cm. at the breech lug, and are turned down to 4 cm. through the breech lug. This design strikes one as being close to the limit of safety as it places these rods, which are not of very great diameter, always under compression.

Elevating Mechanism. The elevating mechanism is operated by hand power only and the ratio of the gearing is five turns of the handwheel for 4 deg. of elevation. The elevating rack is double, although cast in one piece. Identical pinions on the same shaft mesh with these racks. The range of elevation is from zero to 45 deg.

Traversing Mechanism. The traversing mechanism is quite similar to that found on the guns of the Battery Kaiser Wilhelm II. Details of this traversing mechanism are shown in Fig. 27. As with the 305-mm. battery, there is no traversing rack attached to the roller path. The operation is by hand only from a large handwheel located on the left side of the carriage and about on a level with the roller path. In the case of the 305-mm. carriages, the single pinion meshed with spur gears attached to the face of the two large rollers. In this case, the motion from the large handwheel is transmitted directly to only one of the four rollers on which the rear of the carriage is supported. Although the mechanism was seriously damaged, it was possible to traverse the carriage just far enough to indicate that one man could operate the mechanism without difficulty.

Carriage. It was not possible to secure such a photograph of these mounts as would show satisfactorily the construction of the carriage. In general, the design is not unlike that of the carriages for the 305-mm. guns. There are two main girders, each of which is in three sections: a central section of uniform depth, a top section for the trunnion support, and a bottom section carrying the pivot. It is made of standard structural plates and angles throughout. The racer is attached to a heavy yoke which is supported by its trunnions in heavy trunnion bearings attached to

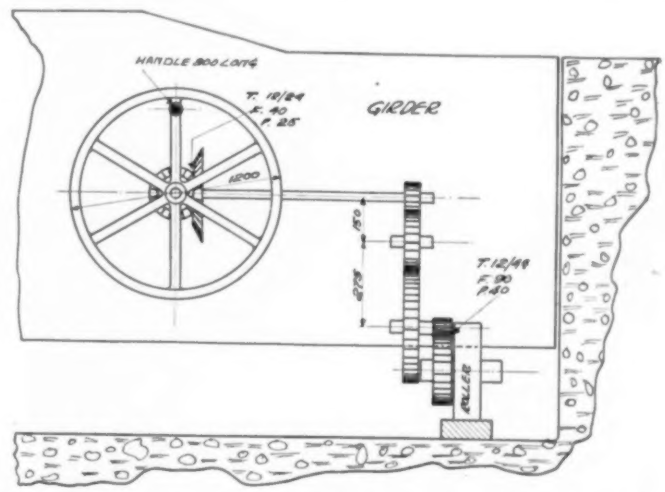

Fig. 27 Battery Tirpitz, 280-mm. Gun Traversing Gear

the carriage. The design of the racer connection with the carriage is not at all unlike that found on the 28-cm. railway mount.

Emplacement. The emplacement is quite similar to that already described for the 305-mm. guns. The traversing roller path is practically identical and the general dimensions of the pit are nearly the same. Again, there is a raised section of concrete in front of the gun, the purpose of which is not apparent. It is understood that unusual difficulties were encountered in constructing these emplacements, inasmuch as the ground is quite swampy, and it was necessary to drive numerous piles in order that the emplacements might be sufficiently stable.

Ammunition-Supply System. The ammunition-supply system for this battery is quite similar to that shown and described for the 305-mm. gun. The shot trucks are of the same design.

Protection. Each of these four guns is armored with 6-cm. flat armor. In spite of the camouflage, the remains of which can be seen in Fig. 23, legible air photographs were secured on August 9, 1916 (see Fig. 28). The camouflage is carried on a framework attached to the carriage and rotates with it. Most of the concrete work about the guns is completely demolished, but there is no evidence that would indicate to the writer that any of the destruction had been effected by shell fire from the sea. It is certain at least that none of the carriages had been so struck or damaged. There are numerous holes to the front and rear of the batteries that were probably made by air bombs.

Battery Groden: 28-Cm. Mortar

Top Carriage. These mortars are supported directly by means of trunnions on a structural-steel top carriage of the design shown in Fig. 24. The carriage was supported on the inclined sides of the main carriage by means of four rollers, two on each side.

Recoil Mechanism. The recoil mechanism comprises two recoil cylinders, the pistons of which were attached to the forward ends of the main carriage body; the cylinders are carried in the sides of the top carriage. The length of recoil is estimated as 1 m., the gun returning to battery by force of gravity. On the front of the main carriage, there are four buffers, each made up of seven pairs of Belleville washers 15 cm. in diameter by 5 mm. in thickness.

Elevating Mechanism. The elevating mechanism comprises a single circular rack bolted to the gun and meshing with a single pinion on a horizontal shaft in the top carriage. The handwheel operating the elevating mechanism is located on the right side of the carriage on a platform rotating with the carriage. On the end of the horizontal shaft in the top carriage, there is a worm wheel meshing with the worm carried on a long shaft parallel to the inclined rails on which the top carriage rolls. The worm is simply keyed to the shaft, moving with the top carriage as it recoils. This is the only elevating mechanism observed in which a slip friction device is provided. This slip friction device provides for the slipping of the worm on the end of the horizontal shaft through the top carriage. In includes two sets of Belleville washers.

FIG. 28 BATTERY TIRPITZ
Air photo taken August 9, 1916.

Traversing Mechanism. The traversing mechanism is made up of one rack attached to the base ring, a traversing pinion, vertical shaft, and simple spur-gear mechanism leading to the handwheel. There is nothing unusual in the design and from the condition of the carriage, it was impossible to traverse it to learn the ratio of the gearing. The extent of traverse is 360 deg.

Carriage. It is believed that the carriage is shown in such detail in Fig. 24 as to make any lengthy description unnecessary. The diameter of the ball path is 3.5 m. and the balls are about 10 cm. in diameter. The carriage is constructed throughout of standard structural steel.

Emplacement. The pit is 6 m. in diameter and 1.5 m. in depth. In front of each mortar there is a concrete parapet about 5 m. high having a slope of about 45 deg. A part of this parapet is shown in Fig. 24. It is evidently a continuation of the concrete storehouse which is covered with earth.

Ammunition-Supply System. The ammunition-supply system is also shown in Fig. 24. Between the shell table and the road a narrow-gage line can be seen which leads to the main storehouse. At the end of the shell table on the concrete floor there are guides to place the shot truck in loading projectiles from the table. It is assumed that the mortars were loaded at zero elevation, although this is not certain. The shot truck is similar in design to those used with the 38-cm. guns and shown in Fig. 10. Since the powder charge is not of great weight, it is probable that it is carried in a two-man tray.

Protection. The only protection afforded these mortars has been mentioned under the heading Emplacement. There was no evidence of any camouflaging, although it is assumed that some sort of camouflage was provided. It is quite certain that no amount of camouflage could effectively conceal them. There is no evidence, however, that any of them had ever been either struck or damaged by shell fire or bombs.

BATTERY GOEBEN: 17-CM. GUN

Gun. All of the guns of this battery (see Fig. 25) are Model 1914, and the gun examined in detail is Model 1914, No. 71-L. Its weight is 10,701 kg., the length of the tube 6.44 m., and the total length of the gun 6.980 m. There are 52 grooves and the twist of the rifling is to the right, 1 cm. in 10. The diameter of the powder chamber is 19 cm. and the breech is of the standard Krupp sliding-wedge type.

Cradle. The cradle is identical in design with the cradle found with the 21-cm. railway mount. There are two hydraulic buffer cylinders, one on the top and the other directly below the cradle, and each is attached to the cradle by a heavy pin about which it can rotate in a vertical plane. Four spring cylinders are arranged about the cradle symmetrically, two above and two below. The diameter of the trunnions is 22 cm. and the length 15 cm.

Recoil Mechanism. The outside diameter of the recoil cylinder is 25 cm. and the estimated length of recoil 40 cm. As noted before, the recuperator cylinders are four in number and they are 1.6 m. in length. There are two columns of springs in each cylinder, the mean diameter of the outside springs being 17 cm., diameter of wire 2.4 cm., and pitch 5 cm. The mean diameter of the inside spring is 11 cm., the diameter of the wire 1.5 cm. and the pitch 3 cm. Tension rods connect the crosshead at the front of each spring column with the recoil lug.

Elevating Mechanism. The elevating mechanism includes a circular rack bolted to the side of the gun near the breech. The pinion meshing with this rack is driven by an electric motor carried on the part of the carriage below the floor.

Traversing Mechanism. A complete circular rack is attached to the base ring. The traversing motor is carried on the section of the top carriage which extends below the deck and connects with the traversing rack through two sets of bevel gears and one spur gear. The entire original gun and turret mechanism, without any modifications, were installed on the concrete emplacement as shown in Fig. 25.

Carriage. The one detail of the carriage which seems of interest to describe is the traversing ball bearing. A portion of the light shield protecting the bearing has been torn away approximately at the center of the turret, and almost above the long exposed anchor bolt. It was found, on removing this shield, that the carriage is provided with a double ball path, the diameter of the outer path being 3.2 m., and the inner path 2.8 m. The balls in the outside bearing are about 5 cm. in diameter and in the inside bearing, 7.5 cm.

Emplacement. These guns, all placed in the shore dunes at Zeebrugge, are easily visible from the sea. The concrete emplacement shown in Fig. 25 is about level with the top of the dune. A railway line, evidently constructed by the Germans, runs along the top of the dune just in front of the gun. The thickness of the concrete wall at the rear is about 1.5 m. This wall increased in thickness on the sides to several meters, flaring off to the right and left at the front. There was a door leading into the operating room under the turret just under the two short anchor bolts seen in the center of the picture.

Ammunition-Supply System. Ammunition was supplied to the gun through the floor just mentioned in the emplacement and was hoisted by the usual type of electrical turret hoist. Apparently there was no provision for supplying ammunition in any other way.

Protection. All of the guns were protected as shown in Fig. 25. This turret was made up of 10-cm. armor.

Destruction. Apparently the usual scheme of destroying the gun was not employed in these cases. Instead, a number of projectiles were detonated inside the turret and in the operating room below. All but one of the emplacements was destroyed as badly as the one shown in Fig. 25. In each case the roof of the turret was blown off. The explosions which destroyed the emplacements do not seem to have destroyed the turret mechanism as one would have expected. In the case of the gun shown there were about half a dozen unexploded projectiles in the turret and twice that number in the operating room below.

Battery Irene: 15-Cm. Gun

Gun. All of the guns of the Battery Irene, Fig. 26, are of the Model 1900, and the gun inspected is Model 1900, No. 478-L. The weight is 4861 kg., the total length 6 m., and the length of the tube to face of the breech block 5.57 m. The number of grooves is 44 and the twist of the rifling is to the right 1 cm. in 10. The diameter of the powder chamber is 18 cm. The breech block is of the standard Krupp sliding-wedge type.

Cradle. The cradle is not unusual in design. The trunnions are provided with an anti-friction device. Two lugs are cast on the bottom of the cradle near the rear to which the recoil piston is attached by means of a pin. Two other lugs are provided to which the spring recuperator cylinders are bolted.

Recoil Mechanism. Attention is called to the rather unique design of the recoil mechanism. This is the only case observed in which the cylinder is carried in the breech lug, the piston being attached to the cradle by means of a pin passing through the two lugs just mentioned. The recuperator cylinders are two in number. Two 3-cm. tension rods connect the breech lug with the crosshead at the forward end of the spring cylinders. These recuperator cylinders are faced off on the inside at the rear to serve as a guide for the breech lug to prevent rotation of the gun.

Other Details. There are no features regarding elevating mechanism, traversing mechanism, carriage, emplacement, ammunition-supply system, or protection that are worthy of description.

Conclusions

Guns. Most of the guns inspected are about 42 calibers in length, measuring from the face of the breech block, or about 45 calibers in total length. All guns are provided with the standard Krupp type of sliding-wedge breech block. In all cases, except with the 28-cm. mortars, which are Model 1892, the twist of the rifling is uniform to the right, 1 cm. in 10. There are no guns older than 1904. Quite a number of the guns are as late as 1916. If the data given in the *Bulletin de Renseignement de l'Artillerie* of January-February, 1919, can be accepted, it is certain that the Germans were securing ranges from these guns at ordinary muzzle velocity far in excess of the ranges that we are securing from our guns. This is probably through the improvement in their projectile design.

Cradles. All cradles constructed may be termed smooth cylinders, and the maximum thickness of the walls is 10 cm. The cradles of the larger guns are provided with bronze liners about 6 mm. thick and 1 m. long, at both forward and rear ends. In all cases, the cradles are provided with the simplest types of brackets for the attaching of the recuperator and recoil cylinders.

Provisions to Prevent Rotation of the Gun. All breech lugs are fastened to the gun by the interrupted-ring method. All lugs are so shaped as to bear either between two recuperator cylinders or on two sides of a single recuperator cylinder to prevent rotation of the gun. There is no evidence in any case of the use of the spline, typical in American design, for the prevention of rotation of the gun.

Hydraulic Buffers. In most cases two hydraulic buffers are provided. Apparently there is no fixed policy of balancing these, since in many cases the two cylinders are located on the bottom of the cradle. In some cases the hydraulic cylinders are provided with extensions on the forward end which are evidently counter-recoil buffers. In a number of other cases no such extensions are visible.

Recuperators. The designers seem to have favored the combined air-spring recuperators for the heavy guns. There is no attempt at balancing them, and the number of cylinders varies from one to four. All of the 380- and 305-mm. guns are provided with only one recuperator cylinder each. As noted under the heading Provisions to Prevent Rotation of Gun, at the bottom of the preceding column, in every case the recuperator cylinders are used as guides for the extension of the breech lug to prevent rotation of the gun.

Gun Carriages—Traversing Mechanisms. In all cases the heavy gun carriages are constructed entirely of structural steel, and with the exception of the 28-cm. mortar carriages, are of the front-pintle type. The pintle bearings in all cases are of the ball type. The rear of the carriages is carried on heavy rollers (two to four in number, 10 to 20 cm. across the face and 0.60 to 1.00 m. in diameter) running on circular tracks set in the concrete emplacement. In some cases (38-cm. guns) the traversing pinion meshes with a rack attached to the roller path. In other cases (380- and 305-mm. guns), the traversing pinion meshes with gears bolted to the face of the rollers.

Elevating Mechanisms. The variations in the design of the elevating mechanisms found in German coast carriages as well as railway carriages is very striking. On the 38-cm. railway mount found at Brussels, and the 305-mm. carriages of the Battery Kaiser Wilhelm II, there are double straight racks, but the dimensions and designs differ quite radically. With the 38-cm. guns of the Batteries Pommern and Deutschland, there are double telescoping screws. On the Battery Tirpitz there is a double curved rack attached to the bottom of the cradle. On the Battery Groden 28-cm. mortars and the guns of several other batteries there are single curved racks attached to the bottom of the cradle. On the Battery Goeben 17-cm. guns circular racks are attached to the sides of the cradles.

Ammunition-Supply System. In all cases the ammunition is conveyed from the storehouses into the gun by hand. The shot trucks are all of extremely simple design, and the projectiles in all cases are rammed by hand.

Ammunition Storage. With all of the heavier batteries, the layout of the ammunition storehouses is as shown in Figs. 17 and 18. In each case the storehouses are designed to house projectiles and powder for the main guns as well as ammunition for the anti-aircraft guns provided for the protection of each of the big batteries.

Protection. It is very significant that there is no evidence of a policy of providing heavy protection for these large-caliber and valuable guns. Apparently all of the guns which are provided with the 6-cm. flat plate armor have been removed from other coast fortifications where they had been previously provided with the same armor. All of the guns were elaborately camouflaged, but air photographs taken in 1916, 1917 and 1918 show quite clearly the positions of all of the guns, ammunition storehouses, approach tracks, etc.

In spite of the lack of protection and the clear evidence of the position of the batteries from air photographs, there is no evidence that any of the guns were ever damaged, or even hit, by shell fire or by bombs from airplanes. It is understood that the coast fortifications were shelled constantly by the heavy guns of the Allies' monitors. The position of the guns were known, but either the smoke screens that were at once put up by the Germans were unusually effective, or the systems of fire control that were employed were defective. The reasons for the failure of the aviators to obtain any satisfactory results are not certain. They dropped many bombs in the vicinity of the various batteries. It is probable that the accuracy of the anti-aircraft guns provided with all of the large batteries was such as to compel the aviators to operate at a very great height.

The Flow of Air Through Small Brass Tubes

By T. S. Taylor,[1] Pittsburgh, Pa.

A study of the flow of air through brass tubes 5/8 in., 7/8 in. and 1½ in. in diameter, respectively, has been made by means of small pitot tubes. Under the conditions of the experiment, it has been observed that the velocity distribution does not become constant in tubes of these dimensions until the air has passed through a length of about 200 cm. The ratio of the average velocity to the maximum velocity at the center has been found to have a value of from 0.82 to 0.85 for all velocities for each of the tubes tested. Tests were made of the influence of dust and oil on the walls of the tubes and very interesting results obtained. A small quantity of dirt irregularly distributed greatly diminishes the total air flow for a given static pressure and also produces a marked change in the velocity distribution, the average velocity being made considerably less with respect to the maximum velocity.

The investigations discussed in the present paper were undertaken as a preliminary study of the general ventilation problem, dealing in particular with the flow of air through tubes of various sizes and shapes. At present, literature on ventilation contains very little information along this particular line that is useful to the designing engineer. Quite a little attention has been given to the mathematical consideration of the flow of liquids through tubes, but so far no special experimental study has been made of the factors influencing the flow of air through small tubes.

In the first place, no very satisfactory device has as yet been made for measuring gas flow through such tubes as are dealt with in the present experiments. The tubes thus far tested in this investigation were of seamless brass having internal diameters of 5/8 in., 7/8 in., and 1½ in. respectively. In order to determine the velocity distribution of the air across these tubes a hot-wire anemometer with thermocouple was developed. The method of use consisted in measuring the electrical energy required in the heating wire to maintain the temperature of the thermocouple a definite amount above the temperature of the air in which it was placed. The device proved to be a very satisfactory one for laboratory experiments. For shop use, however, it is not satisfactory as it requires accurate manipulation and is not "fool-proof." Attention was therefore turned to the usual pitot-tube method. In the preliminary study it was only necessary to have a tube for measuring the total pressure, as the static pressure could be measured by means of a small tube in the side of the main tube through which the air was passing. The pitot tubes used were made from hypodermic needles about 5/64 in. in external diameter. The velocity pressure was measured in the usual way by means of inclined oil gages. The use of a special low-pressure differential gage was found unnecessary.

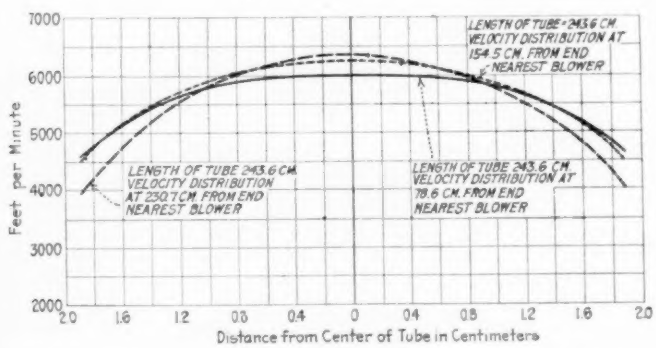

Fig. 1 Velocity Distribution at Three Points in 1½-in. Tube

The air current was furnished by means of a No. 3 V blower made by the American Blower Co., and was driven by a d.c. variable-speed motor. To prevent vibration of blower and motor being transmitted to the tube, a short rubber hose was used for connection between blower outlet and the brass tube used in the experiment. From the readings of the inclined gage the velocity of the air was calculated by the usual formula

$$V = \sqrt{2ghd/d'}$$

where g is gravity, h the difference in level in the gage, d the density of the medium in the gage, and d' the density of the air. All velocities were calculated and reduced to standard conditions of 760 mm. pressure and air temperature of 25 deg. cent.

Velocity Distribution

A study was made of the velocity distribution at various positions along a 1½-in. brass tube 243.6 cm. (8 ft.) long. This was done with a pitot tube about 1/40 in. (0.068 cm.) in external diameter inserted into the brass tube. The curves in Fig. 1 show the distribution of velocity for three different positions. The velocity at the center of the tube is seen to increase as the distance from the end nearest the blower increases. The average velocity for each of the cases is 5300 ft. per minute. This average velocity was obtained in the following manner. The cross-section of the tube was divided into several small concentric zones and the area of each zone calculated. The area of each zone was then multiplied by its average velocity. The sum of the products for all zones was then divided by the area of the cross-section of the tube, which gave the average or mean velocity of air flow. In other words, this is equivalent to finding the volume described by revolving the curve for the velocity distribution about its axis and dividing this volume by the area of the tube. These results show clearly that the velocity distribution of air flowing through tubes does not reach a steady state in the distance in which it is usually assumed that it does. It is customary to assume a steady distribution to exist in a length of tube equivalent to 10 times its diameter.

In order to test this last point a little more, a second tube 407 cm. (13.3 ft.) long and 1½ in. in diameter was used. It was found that the velocity distribution had attained a definite condition and was the same for all points distant 200 cm. from the blower end of the tube. Another rather interesting point was observed in regard to the ratio of the average velocity to the maximum velocity for various velocities. The results in Table 1

TABLE 1 SHOWING RATIO OF AVERAGE VELOCITIES TO MAXIMUM VELOCITY AT VARYING AIR VELOCITIES IN 1½ IN. BRASS TUBE

Blower Speed r.p.m.	Static Pressure in Inches.	Maximum Velocity ft. per min.	Average Velocity ft. per min.	Average Ratio. =Avg. Max.
435	0.0465	872	751	0.862
739	0.0913	1410	1186	0.853
983	0.146	1912	1610	0.842
1098	0.176	2144	1804	0.842
1490	0.322	2973	2480	0.834
1857	0.437	3784	3216	0.850
2710	0.980	5373	4460	0.830
3150	1.385	6330	5460	0.863
General Mean				0.847

[1] Mellon Institute, University of Pittsburgh, formerly of the Westinghouse Electric and Manufacturing Co., East Pittsburgh, in whose Research Laboratory the work herein described was done.

Abstract of a paper presented at the Spring Meeting, St. Louis, May 24 to 27, 1920, of The American Society of Mechanical Engineers. Copies of the complete paper may be obtained upon application. All papers are subject to revision.

show that the average velocity is the same percentage of the maximum velocity for all velocities from 800 ft. per min. to 6300 ft. per min. These results were all taken in the long tube, 407 cm., at a point 240 cm. from the end adjacent the blower. The values of the static pressure were taken at the point along the tube when the velocity distribution was determined, and thus represent the pressure which is necessary to maintain the air flow through the remainder of the tube, or 167 cm. The fact that this ratio of the average velocity to the maximum is approximately the same for all velocity distribution, seems quite interesting. Similar results were also obtained for tubes 7/8 in. and 5/8 in. in diameter, respectively. The general mean for the ratio of the average to the maximum velocity was found to be 0.830 for the 7/8-in. tube and 0.870 for the 5/8-in. tube. These results would indicate that there is little difference between these ratios for different-sized tubes provided the surface conditions are identical. These results indicate also that the velocity distribution, for steady state, across smooth brass tubes having similar surface conditions is practically the same for all tubes and all average velocities between 0 and 6000 ft. per min. It is interesting to note that the velocity near the wall of the tube is so large as compared with the maximum velocity at the center. The velocity must therefore drop off very rapidly close to the wall of the tube. This drop occurs in such a short distance that it cannot be observed with a pitot tube 1/40 in. in diameter.

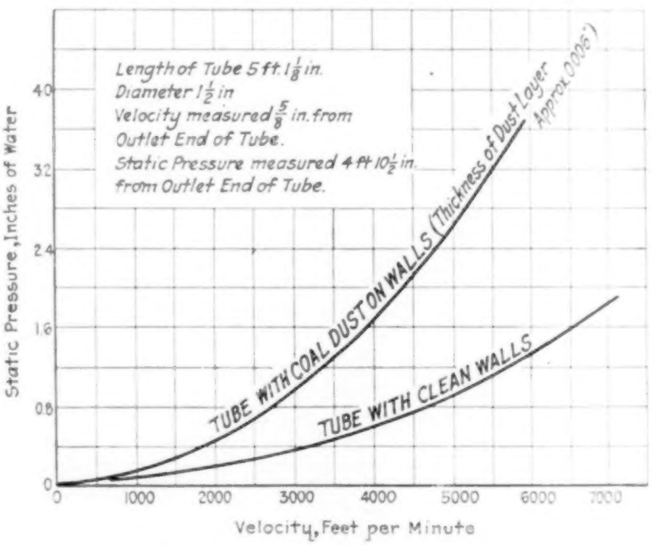

FIG. 2 EFFECT OF DUST IN TUBE

EFFECT OF DUST IN TUBES

Having determined the above data on the air flow through smooth tubes, the next step was to see what effect would be produced by the addition of dust to the walls of the tubes. Oil was poured through brass tubes 1 1/2 in., 7/8 in. and 5/8 in. in diameter respectively, each being a little over 5 ft. long. Coal dust was then sifted through the tube and only that was allowed to remain which was not readily jarred out when the end of the tube was struck against some object. The velocity across each tube was then measured near the outlet end for various air velocities. The thickness of the dirt layer is only approximate. The dust and oil were wiped out of the tubes after measurements were taken and the thickness of the layer determined from its mass and density. The results obtained are summarized in Table 2.

The curves in Fig. 2 show the difference in the static pressure necessary to force air at various average velocities through clean and dirty tubes as specified in the figure. They show that a very small but irregular distribution of dirt upon the surface of smooth tubes will have a very decided effect upon the amount of air that will pass through the tube for a given static pressure. The effect is not merely a diminution in the effective area of cross-section but must give rise to turbulency since the ratio of the average velocity to the maximum is so much influenced by the presence of the dirt. The diminution in this ratio due to the dirt must depend chiefly upon the manner in which the dirt is distributed. At any rate the distribution must be of considerably more importance than the amount per unit area, as can be seen by reference to Table 2 and Fig. 2. The values of the static pressure to maintain an average velocity of 3000 ft. per min. through the tubes when clean and dirty as outlined above are given in Table 3.

TABLE 2 INFLUENCE OF LAYER OF DIRT ON VELOCITY DISTRIBUTION IN TUBES

Diameter in.	Clean Tube, Avg. V/Max. V.	Dirty Tube Avg. V/Max. V.	Thickness of Layer, in.
1 1/2	0.832	0.75	0.006
7/8	0.833	0.65	0.016
5/8	0.825	0.80	0.008

TABLE 3 STATIC PRESSURE IN INCHES OF WATER NECESSARY TO MAINTAIN AVERAGE VELOCITY OF 3000 FT. PER MIN. IN TUBES 5 FT. LONG

Diameter of Tube in.	Static Pressure, in. of Water		Thickness of Layer, in.
	Clean Tube	Dirty Tube	
1 1/2	0.37	0.94	0.006
7/8	0.80	3.20	0.0016
5/8	1.00	5.00	0.008

While the results of the present experiments should be considered as only preliminary, they nevertheless bring out some rather interesting points. The striking features about them are to be found: (*a*) in the way in which the velocity distribution changes along a tube; (*b*) in the relative relation of the ratios of average velocity to maximum velocity for different tubes as well as different velocities; and (*c*) in the influence that dust collected upon the wall of a tube exercises upon the total flow of air under a definite static pressure.

In conclusion, I take pleasure in acknowledging my indebtedness to the Westinghouse Electric and Manufacturing Company, in whose research laboratory the work was done, for furnishing the facilities for carrying out the experiments, and in particular to Mr. C. E. Nolan for his able assistance throughout the work.

An instrument for determining the direction of flow of fluids in pipes is described by Mr. J. S. G. Thomas in a paper entitled A Directional Hot-Wire Anemometer of High Sensitivity, especially Applicable to the Investigation of Low Rates of Flow of Gases, recently presented to the Physical Society. Essentially the instrument consists of two fine platinum wires arranged parallel and one behind the other in close juxtaposition, transversely to the direction of flow of gas in the pipe. The wires constitute two arms of a Wheatstone bridge, the remaining arms being formed of a resistance of 1000 ohms and an arm capable of adjustment. The operation is dependent upon the fact that that platinum wire experiences the greater cooling effect upon which the stream of gas is first incident, since it exercises by its presence a shielding effect upon the second wire. Such a hot-wire anemometer affords a ready means of ascertaining the direction of flow of fluids in various units of a complicated network of gas or other mains. The author states that subsequent experience with anemometers of this type has shown that they possess special characteristics which make them particularly useful in the investigation of very low rates of flow.—*The Engineer* (London), April 16, 1920.

THE ENGINEER'S RELATION TO PUBLIC QUESTIONS

Address of President Miller at the Banquet Given by the Western Society of Engineers to the Governing Boards of the Four National Societies

ON another page will be found an account of the two-day conference held April 19 and 20 in Chicago, when the members of the governing boards of the A.S.C.E., A.I.M.E., A.I.E.E. and A.S.M.E. were the guests of the Western Society of Engineers. President Miller's remarks at the banquet given in the Hotel La Salle on the evening of the 19th follow:

It gives me the greatest pleasure to meet along with my fellow-engineers from the outlying districts of Chicago, extending from the Pacific to the Atlantic, with your Society of Western Engineers, which, I am told, is, in point of age, the third society among engineering associations in this country. In fact, it is about as old as I am.

Now, an individual can attain age simply by continuing to exist, but no society can do that. A society or an organization of any kind, not subsidized, cannot attain the age that I have attained unless it does something that is creditable and worth while, and we all know that the Western Society of Engineers has much more to its credit than mere existence since its foundation.

The American Society of Mechanical Engineers, which I have the honor to represent, has always shown a considerable spirit of progress and coöperation. I think its members generally recognize that the engineer is by tradition and training an innovator. His work renders valuable that which before perhaps had no value, and, on the other hand, sometimes renders of no value that which previously had value. Those are necessary consequences of the engineer's work. The engineer, this being the case, should, I think, be willing to take his own medicine and societies, no matter how old they may become, should retain that attribute of youth which enables us to consider and to study and perchance to adopt new ideas.

Our society, immediately following the appointment by the Civil Engineers of their committee to consider the problems now before the engineering societies concerning coöperation, appointed a committee which we called the "Aims and Organization Committee." That committee, after considerable conscientious and hard work, submitted a report advocating considerable changes in our Society, particularly along the lines of democratization of its administrative features, and strongly recommended coöperation with other engineering societies. None of us can be certain of what will happen in the future, but I think it is easy to predict that the time will come when there will be in Chicago, by the growth of engineering in this neighborhood, a headquarters building of engineering somewhat similar to the United Engineering Societies Building in New York. In that building probably will be housed all the engineering interests of this section, and I believe it is easy to perceive and to predict that it will eventually house branch offices of the principal engineering societies of the country; and, if we allow our imagination to go a little further, we might imagine that by the development that may take place in the future those branch offices may, as sometimes happens in other organizations, become really the principal offices of those associations.

THE ENGINEER AND PUBLIC QUESTIONS

It is generally expected that in our joint activities we shall attempt to deal more than ever before, and especially more effectively than ever before, with matters of public concern. Our relation to those problems will necessarily be of a twofold nature: for first, we are citizens of a great country, with the duties and responsibilities that pertain to that citizenship; and after that we are engineers, with duties and responsibilities not only to ourselves and those dependent on us, but to the high and honorable profession to which we belong.

With respect to purely engineering matters engineers can and will speak with the authority of experts, but all public questions connected with engineering will have, or nearly all will have, an aspect of public policy, and I think we will do well to remember, in discussing these matters, that we will do best to confine ourselves to the purely technical side of those questions, for we must remember that where a question has a public aspect, other citizens of the United States, not engineers, will have as much right and will be as much expected to hold and to express views upon those matters as we; and our testimony as engineers will have the more effect if we carefully refrain from giving the impression that we assume any extraordinary or special ability regarding the public side of those questions that may come before us. We can be, in a sense, expert witnesses, testifying for what we believe to be right, but with all the well-understood limitations of the expert witness (Laughter); and our influence on the expert or on the technical side of these questions will be the greater in proportion as we confine ourselves to that side of the matter.

It is obvious that our own members will have various views regarding the public questions which arise, and for that reason I think we should also be very cautious about affiliations of our engineering societies with other organizations not composed of engineers nor having engineering objects, because if we attempt to commit our members to questions not dealing strictly with engineering matters, then our own members will have widely varying views on those matters, and by attempting to commit our members to them we shall, I fear, promote dissension and possibly disintegration. I think it is well we should bear that in mind and be cautious about such affiliation and joint action.

THE ENGINEER AND PUBLICITY

Finally, if we are to serve the public, the public must know much more about the engineers' work than it has been able to discover heretofore, and that means publicity, a thing which the engineers have not cultivated as they should, and which I think needs a great deal more attention than has been given it. Recently, the annual banquet of a society of engineers in a New England city was held, and at that banquet the governor of the state, the mayor of the city, the representatives of the four engineering societies, and others, spoke. The governor of the state and the mayor of the city spoke remarkably well regarding the coöperation of engineers with public matters in the service of the state and of the municipality. The mayor of the city particularly said that certain activities carried on under the advice and with the help of engineering associations of that locality had been carried on much better than ever had been possible before. Further, he stated flat-footedly that he believed the time had come when it must be recognized that the activities of a municipality involving engineering matters could no longer be satisfactorily conducted under the control of politicians, but must be conducted under the guidance and control of engineers—a very significant thing to be said by the mayor of a great city of this country.

The day after that meeting took place the papers of the city were examined to see how they had treated this occasion. One had in its headlines the name of a prominent lawyer who had spoken well at the meeting on an important matter of international politics, but no reference to engineers nor to an engineering meeting. The article went on to say that the lawyer had said certain things on this subject at a meeting of engineers held the night before. That was all the publicity that the engineers of the city secured from the occasion, although the speeches were filled with matter of the utmost importance to the public if it could have been gotten to them.

Now, it has seemed to me that the engineers need to cultivate that particular thing, and that we shall do better if the local societies of engineers can select some one of their number who can, in coöperation with a newspaperman knowing the newspaper game, translate into human and public terms what it is that the engineers are trying to do, why they are trying to do it, and what it means to the public. The newspaper game is a good deal like any other game. One who takes part in it and succeeds must know the game; he must know what will interest the city editor and in what form it will interest him, and engineers are not trained for that work. They see only the engineering side of it. The newspaper man can see the human side of it, and with the assistance of the engineer I believe a combination can usually be made in any locality that will secure for engineers at least a part of the publicity to which they are entitled, and which they ought to have.

This will not be selfish advertising. The public needs our coöperation, but in order to secure that coöperation it needs to understand what we are doing. It is a matter of human experience that when groups of people wish to coöperate or to work together, they cannot do so effectively until each group understands what the other purposes to do, how it proposes to do it, and why it proposes to do it, and that means publicity, which I recommend be given much more attention than engineers have been in the habit of giving it heretofore.

A new chemical reagent which has proved to be one of the most striking solvents discovered in recent years and contains possibilities of extensive industrial use has recently been worked out in the chemical laboratories of the University of Wisconsin. The discovery was announced at the meeting of the American Chemical Society in St. Louis recently by Prof. Victor Lenher, the chemist who conducted the investigation.

The new solvent is technically known as selenium oxychloride, and the selenium from which it is made is a by-product in the electrolytic refining of copper, a substance for which there is now no market, although hundreds of tons of it are annually going to waste.

The reagent is an excellent solvent for unsaturated organic substances. The unsaturated hydrocarbons, such as acetylene, benzine toluene, etc., dissolve readily in it, while the paraffin hydrocarbons, such as gasoline, kerosene and the so-called mineral waxes, vaseline and paraffin, are unaffected. The vegetable oils are acted upon, many with violence, and linseed oil forms a thick, exceedingly mucilagenous and rubberlike mass.

Bakelite, redmanol, the waterproof insoluble casein glue used in airplane construction, pure rubber, vulcanized rubber, asphalt and bitumen all dissolve with ease. The bituminous material in soft coal can be dissolved out, leaving a carbonaceous residue, and in all probability some information as to the character of the naturally occurring asphalts and bitumens can be obtained by the use of this new solvent.

National Screw Thread Commission Report

This Commission, Composed of Engineers and Government Representatives, Is the First to Be Appointed by Congress for Standardization Work. The Report Covers Standards for Threads and Thread Gages, Including Tolerances

As a result of the efforts of the American Society of Mechanical Engineers, the Society of Automotive Engineers, the Bureau of Standards and prominent manufacturers of specialized thread products, the National Screw Threads Commission was appointed by Act of Congress, July 16, 1918, to investigate and collate standards for screw threads to be adopted by manufacturing plants under the control of the army and navy, and also for adoption and use by the public. The work of organizing the Commission was expedited by the Committee on Coinage, Weights, and Measures of the Department of the Interior, and it was under their auspices that the act was modified on March 3, 1919, to take care of changes in the requirements of the personnel and to extend the life of the Commission until March 21 of this year; and again on March 1, when the life of the commission was extended for two years.

The Commission is composed of two representatives of the army, two representatives of the navy, and four civilians nominated by the engineering societies of America, with Dr. S. W. Stratton, Director of the Bureau of Standards, as chairman. The members serve without compensation with the exception of the regular salaries received by the army and navy members and that received by the Director of the Bureau of Standards.

The work for which the Commission was created, which, in the opinion of Dr. Stratton, is one of far-reaching effect, has been largely completed by the issuance of a progress report, a copious abstract of which is given herewith. The report is very complete in its text and includes, in addition, a large number of diagrams and tables. A few of the latter are included in the abstract.

It was believed best to keep the Commission in existence for two years more, so that it may pass upon any questions of adjustment or modification of the proposed standards. The appointees of The American Society of Mechanical Engineers serving on the Commission are James Hartness and F. O. Wells.—Editor.

ABSTRACT OF REPORT

It is the desire of the Commission to make available to American manufacturers the information contained in its progress report for immediate use, rather than delay making a report in order to consider more fully the possibilities of international standardization of screw threads. It is the opinion of the Commission, however, that international standardization of screw threads is very desirable and that the present time is most opportune for accomplishments in this direction.

In 1864 a committee appointed by The Franklin Institute, Philadelphia, prepared a report upon its investigations of a proper system of screw threads, bolt heads and nuts, which recommended the thread system developed by William Sellers, known at present as the Franklin Institute Thread, Sellers Thread, or more generally as the United States Thread. The accomplishment realized in the general adoption of the United States Standard Thread was brought about largely by the great need of standard threads by American railroads. Certain other industries, however, such as the automobile, machine-tool, and light machine industries, were in need of additional standard threads, and to fulfill these needs a thread system having finer pitches was recommended by the Society of Automotive Engineers; and a machine-screw thread series which provided smaller-sized screws than the United States Standard Thread was recommended by The American Society of Mechanical Engineers.

Thread Series Recommended

It was the aim of the Commission, in establishing thread systems for adoption and general use, to eliminate all unnecessary sizes, in addition to utilizing, as far as possible, present predominating sizes. While from certain standpoints it would have been desirable to make simplifications in the thread systems and to establish more thoroughly consistent standards, it is believed that any radical change at the present time would interfere with manufacturing conditions and involve great economic loss.

The testimony given at the various hearings held by the Commission is very consistent in favoring the maintenance of the present coarse- and fine-thread series. The coarse-thread series is the present United States Standard thread series supplemented in the sizes below 1/4 in. by the standard established by The American Society of Mechanical Engineers for machine screws. This series includes only those sizes which are essential and is recommended for general use in engineering work, in machine construction where conditions are favorable to the use of bolts, screws, and other threaded components where quick and easy assembly of the parts is desired, and for all work where conditions do not require the use of fine pitch threads. (Table 1.)

TABLE 1 NATIONAL COARSE-THREAD SERIES

Identification		Basic Diameters				Thread Data	
1	2	3	4	5	6	7	8
Numbered and Fractional Sizes	n Number of Threads per Inch	D Major Diam., Inches	E Pitch Diam., Inches	K Minor Diam., Inches	Metric Equivalent to Major Diam., mm.	p Pitch, Inches	h Depth of Threads Inches
1	64	0.073	0.0629	0.0527	1.854	0.0156250	0.0101
2	56	0.086	0.0744	0.0628	2.184	0.0178571	0.0116
3	48	0.099	0.0855	0.0719	2.515	0.0208333	0.0135
4	40	0.112	0.0958	0.0795	2.845	0.0250000	0.0162
5	40	0.125	0.1088	0.0925	3.175	0.0250000	0.0162
6	32	0.138	0.1177	0.0974	3.505	0.0312500	0.0203
8	32	0.164	0.1437	0.1234	4.166	0.0312500	0.0203
10	24	0.190	0.1629	0.1359	4.826	0.0416667	0.0271
12	24	0.216	0.1889	0.1619	5.486	0.0416667	0.0271
1/4	20	0.2500	0.2175	0.1850	6.350	0.0500000	0.0325
5/16	18	0.3125	0.2764	0.2403	7.938	0.0555556	0.0361
3/8	16	0.3750	0.3344	0.2938	9.525	0.0625000	0.0406
7/16	14	0.4375	0.3911	0.3447	11.113	0.0714286	0.0464
1/2	13	0.5000	0.4500	0.4001	12.700	0.0769231	0.0500
9/16	12	0.5625	0.5084	0.4542	14.288	0.0833333	0.0541
5/8	11	0.6250	0.5660	0.5069	15.875	0.0909091	0.0590
3/4	10	0.7500	0.6850	0.6201	19.050	0.1000000	0.0650
7/8	9	0.8750	0.8028	0.7307	22.225	0.1111111	0.0722
1	8	1.0000	0.9188	0.8376	25.400	0.1250000	0.0812
1 1/8	7	1.1250	1.0322	0.9394	28.575	0.1428571	0.0928
1 1/4	7	1.2500	1.1572	1.0644	31.750	0.1428571	0.0928
1 1/2	6	1.5000	1.3917	1.2835	38.100	0.1666667	0.1083
1 3/4	5	1.7500	1.6201	1.4902	44.450	0.2000000	0.1299
2	4 1/2	2.0000	1.8557	1.7113	50.800	0.2222222	0.1443
2 1/4	4 1/2	2.2500	2.1057	1.9613	57.150	0.2222222	0.1443
2 1/2	4	2.5000	2.3376	2.1752	63.500	0.2500000	0.1624
2 3/4	4	2.7500	2.5876	2.4252	69.850	0.2500000	0.1624
3	4	3.0000	2.8376	2.6752	76.200	0.2500000	0.1624

The fine-thread series is made up of sizes taken from the standards of the Society of Automotive Engineers. This series is recommended for general use in automotive and aircraft work, for use where the design requires both strength and reduction in weight, and where special conditions require a fine thread, such as, for instance, on large sizes where sufficient force cannot be secured to set properly a screw or bolt of coarse pitch by the use of an ordinary wrench. (Table 2.)

The adoption, in practically its present form, of the American Briggs Standard Pipe Thread sizes as recommended by The American Society of Mechanical Engineers and all other organizations in any way interested in pipe threads was heartily favored by the great majority. This also applies to the fire-hose-coupling pitches as established by the National Fire Protection Association.

The National Fire Hose Coupling Threads Series is for fire-hose couplings from 2½ in. to 4½ in. in diameter, the basic sizes and dimensions of which correspond in all details to those recommended by the National Fire Protection Association, by the

TABLE 2 NATIONAL FINE-THREAD SERIES

Identification		Basic Diameters			Thread Data		
1	2	3	4	5	6	7	8
Numbered and Fractional Sizes	n Number of Threads per Inch	D Major Diam., Inches	E Pitch Diam., Inches	K Minor Diam., Inches	Metric Equivalent to Major Diam., mm.	p Pitch, Inches	h Depth of Threads Inches
0	80	0.060	0.0519	0.0438	1.524	0.0125000	0.00812
1	72	0.073	0.0640	0.0550	1.854	0.0138889	0.00902
2	64	0.086	0.0759	0.0657	2.184	0.0156250	0.01014
3	56	0.099	0.0874	0.0758	2.515	0.0178571	0.01160
4	48	0.112	0.0985	0.0849	2.845	0.0208333	0.01353
5	44	0.125	0.1102	0.0955	3.175	0.0227273	0.01476
6	40	0.138	0.1218	0.1055	3.506	0.0250000	0.01624
8	36	0.164	0.1460	0.1279	4.166	0.0277778	0.01804
10	32	0.190	0.1697	0.1494	4.826	0.0312500	0.02030
12	28	0.216	0.1928	0.1696	5.486	0.0357143	0.02319
1/4	28	0.2500	0.2268	0.2036	6.350	0.0357143	0.02319
5/16	24	0.3125	0.2854	0.2584	7.938	0.0416667	0.02706
3/8	24	0.3750	0.3479	0.3209	9.525	0.0416667	0.02706
7/16	20	0.4375	0.4050	0.3725	11.113	0.0500000	0.03248
1/2	20	0.5000	0.4675	0.4350	12.700	0.0500000	0.03248
9/16	18	0.5625	0.5264	0.4903	14.288	0.0555556	0.03608
5/8	18	0.6250	0.5889	0.5528	15.875	0.0555556	0.03608
3/4	16	0.7500	0.7094	0.6688	19.050	0.0625000	0.04060
7/8	14	0.8750	0.8286	0.7822	22.225	0.0714286	0.04640
1	14	1.0000	0.9536	0.9072	25.400	0.0714286	0.04640
1 1/8	12	1.1250	1.0709	1.0167	28.575	0.0833333	0.05413
1 1/4	12	1.2500	1.1959	1.1417	31.750	0.0833333	0.05413
1 1/2	12	1.5000	1.4459	1.3917	38.100	0.0833333	0.05413
1 3/4	12	1.7500	1.6959	1.6417	44.450	0.0833333	0.05413
2	12	2.0000	1.9459	1.8917	50.800	0.0833333	0.05413
2 1/4	12	2.2500	2.1959	2.1417	57.150	0.083333	0.05413
2 1/2	12	2.5000	2.4459	2.3917	63.500	0.083333	0.05413
2 3/4	12	2.7500	2.6959	2.6417	69.850	0.083333	0.05413
3	10	3.0000	2.9350	2.8701	76.200	0.100000	0.06495

Bureau of Standards, and by The American Society of Mechanical Engineers. This series is to be used on all couplings and hydrant connections for fire-protection systems and for all other purposes where hose couplings and connections are required in sizes between 2½ in. and 4½ in. in diameter. (Table 3.)

TABLE 3 NATIONAL FIRE-HOSE COUPLINGS

BASIC MINIMUM COUPLING DIMENSIONS

Nominal Size	Number of Threads per In.	Pitch Inches	Depth of Thread Inches	Major Diameter mm.	Major Diameter Inches	Pitch Diam., Inches	Minor Diam., Inches	Allowance, Inches
2.5000	7.5	0.13333	0.0955	78.550	3.0925	2.9970	2.9015	0.03
3.0000	6.0	0.16667	0.1243	92.837	3.6550	3.5307	3.4063	0.03
3.5000	6.0	0.16667	0.1243	108.712	4.2800	4.1556	4.0313	0.03
4.5000	4.0	0.25000	0.1765	147.320	5.8000	5.6235	5.4470	0.05

BASIC MAXIMUM NIPPLE DIMENSIONS

2.5000	7.5	0.13333	0.0955	77.788	3.0625	2.9670	2.8715	0.03
3.0000	6.0	0.16667	0.1243	92.075	3.6250	3.5006	3.3763	0.03
3.5000	6.0	0.16667	0.1243	107.950	4.2500	4.1256	4.0013	0.03
4.5000	4.0	0.25000	0.1765	146.050	5.7500	5.5735	5.3970	0.05

The National Hose Coupling Threads Series is for hose-coupling threads from ¾ in. to 2 in. in diameter. These are to be used on all couplings and connections where sizes between ¾ in. and 2 in. in diameter are required. (Table 4.)

The National Pipe Thread Series is described in detail in the section on National (American) Pipe Threads.

FORM OF THREAD

The form of thread profile, known previously as the United States Standard or Sellers Profile, which was recommended by the Commission, is known throughout the report as the National Form of Thread. This profile is to be used for all screw-thread work except when otherwise specified for special purposes. The basic angle of thread between the sides of the thread measured in an axial plane is 60 deg. The line bisecting this 60-deg. angle is perpendicular to the axis of the screw thread. The basic flat at the root and crest of the thread form is $\frac{1}{8}\,p$ or $0.125\,p$. The basic depth of the thread form is $0.649519p = 0.649519/n$, where p is the pitch in inches and n the number of threads per inch. A clearance is provided at the minor diameter of the nut by removing the thread form at the crest by an amount equal to ⅙ to ¼ of the basic thread depth. A clearance at the major diameter of the nut is provided by decreasing the depth of the truncation triangle by an amount equal to ⅓ to ⅔ of its theoretical value.

For threads cut on fire-hose couplings, the form of the thread profile recommended by the National Fire Protection Association, The American Society of Mechanical Engineers and the Bureau of Standards, and previously known and specified as the National Standard Hose Coupling Thread, is specified in this report as follows:

The basic angle between the sides of the thread measured in an axial plane is 60 deg. The line bisecting this 60-deg. angle is perpendicular to the axis of the screw thread. The crest and root of the basic thread are flattened or truncated from a sharp V form as follows:

Threads per inch	4	6	7½
Depth of truncation, inches	0.02	0.01	0.01

TABLE 4 NATIONAL HOSE-COUPLING THREADS

BASIC MINIMUM COUPLING DIMENSIONS

Nominal Size	Number of Threads per In.	Pitch Inches	Depth of Thread Inches	Major Diameter mm.	Major Diameter Inches	Pitch Diam., Inches	Minor Diam., Inches	Allowance, Inches
3/4	11 1/2	0.08696	0.0565	27.242	1.0725	1.0160	0.9595	0.01
1	11 1/2	0.08696	0.0565	33.150	1.3051	1.2486	1.1922	0.01
1 1/4	11 1/2	0.08696	0.0565	41.908	1.6499	1.5924	1.5369	0.01
1 1/2	11 1/2	0.08696	0.0565	47.976	1.8888	1.8323	1.7759	0.01
2	11 1/2	0.08696	0.0565	60.015	2.3628	2.3063	2.2498	0.01

BASIC MAXIMUM NIPPLE DIMENSIONS

3/4	11 1/2	0.08696	0.0565	26.988	1.0625	1.0060	0.9495	0.01
1	11 1/2	0.08696	0.0565	32.696	1.2951	1.2386	1.1822	0.01
1 1/4	11 1/2	0.08696	0.0565	41.654	1.6399	1.5834	1.5269	0.01
1 1/2	11 1/2	0.08696	0.0565	47.722	1.8788	1.8223	1.7659	0.01
2	11 1/2	0.08696	0.0565	59.761	2.3528	2.2963	2.2398	0.01

CLASSIFICATION OF FITS

For general use, four distinct classes of screw-thread fits were established. These four classes, together with the accompanying specifications, given below and in Tables 5, 6, 7 and 8, are for the purpose of insuring interchangeable manufacture of screw-thread parts throughout the country. The examples given under each class of fit are for the purpose of illustration only. It is not the intention of the Commission to arbitrarily place a general class or grade of work in a specific class of fit. Each manufacturer and user of screw threads is free to select the class of fit best adapted to his particular needs.

The following general specifications apply to all classes of fits: In order to conform to the general ideas of standardization, the pitch diameter of the minimum threaded hole or nut should correspond to the basic size, the errors due to workmanship being permitted above the basic size. The maximum length of engagement for screw threads manufactured in accordance with any of the classes of fit specified herein shall not exceed the quantity as determined by the formula $L = 1.5D$, where L is the length of engagement and D the basic major diameter of the thread.

The specifications established for the various classes of fit are applicable to the National Coarse Threads, the National Fine Threads, the National Hose Threads, Straight Pipe Threads, and to any special thread required in manufacture which is not intentionally tapered.

CLASS I, LOOSE FIT

The loose-fit class of screw threads is defined and specified as follows: This class is intended to cover the manufacture of strictly interchangeable threaded parts where the work is produced in two or more manufacturing plants. In this class are included threads for artillery ammunition and rough commercial work, such as stove bolts, carriage bolts, and other threaded work of a similar nature, where quick and easy assembly is necessary and a certain amount of shake or play is not objectionable. National Straight Pipe Threads and National Hose Coupling Threads are to be produced in this class of fit only. National Fire Hose Threads are to be produced in this class in accordance with special allowances and tolerances for fire-hose-coupling

threads. The pitch diameter of the minimum nut of a given diameter and pitch will correspond to the basic pitch diameter as specified in the tables of thread systems given herein, which is computed from the basic major diameter of the thread to be manufactured. The pitch diameter of the minimum nut is the theoretical pitch diameter for that size.

The tolerance on the nut will be plus, applied from the basic size to above basic size; the tolerance on the screw will be minus, applied from the maximum screw dimensions to below the maximum screw dimensions. The allowance provided between the size of the minimum nut, which is basic, and the size of the maximum screw for a screw thread of a given pitch, and the tolerance allowed on a screw or nut of a given pitch will be as specified in Table 5.

TABLE 5 CLASS I—LOOSE FIT
ALLOWANCES AND TOLERANCES
SCREWS, NUTS AND GAGES

1	2	3	4	5	6	7
			MASTER GAGE TOLERANCES			
No. Thds. per Inch	Allowances, Inches	Extreme or Drawing Pitch Diam. Tolerances, Inches	Diameter, Inches	Lead, (+ or −) Inches	1/2 Angle, (+ or −) Degrees	Net Pitch Diameter Tolerances, Inches
80	0.0007	0.0024	0.0002	0.0002	30' 00"	0.0020
72	0.0007	0.0025	0.0002	0.0002	30' 00"	0.0021
64	0.0007	0.0026	0.0002	0.0002	30' 00"	0.0022
56	0.0008	0.0028	0.0002	0.0002	30' 00"	0.0024
48	0.0009	0.0031	0.0002	0.0002	30' 00"	0.0027
44	0.0009	0.0032	0.0002	0.0002	30' 00"	0.0028
40	0.0010	0.0034	0.0002	0.0002	20' 00"	0.0030
36	0.0011	0.0036	0.0002	0.0002	20' 00"	0.0032
32	0.0011	0.0038	0.0002	0.0002	20' 00"	0.0034
28	0.0012	0.0043	0.0003	0.0002	15' 00"	0.0034
24	0.0013	0.0046	0.0003	0.0002	15' 00"	0.0040
20	0.0015	0.0051	0.0003	0.0002	15' 00"	0.0045
18	0.0016	0.0057	0.0004	0.0003	10' 00"	0.0049
16	0.0018	0.0063	0.0004	0.0003	10' 00"	0.0055
14	0.0021	0.0070	0.0004	0.0003	10' 00"	0.0062
13	0.0022	0.0074	0.0004	0.0003	10' 00"	0.0066
12	0.0024	0.0079	0.0004	0.0003	10' 00"	0.0071
11	0.0026	0.0085	0.0004	0.0003	10' 00"	0.0077
10	0.0028	0.0092	0.0004	0.0004	5' 00"	0.0084
9	0.0031	0.0100	0.0004	0.0004	5' 00"	0.0092
8	0.0034	0.0111	0.0004	0.0004	5' 00"	0.0103
7	0.0039	0.0124	0.0004	0.0004	5' 00"	0.0116
6	0.0044	0.0145	0.0006	0.0005	5' 00"	0.0133
5	0.0052	0.0169	0.0006	0.0005	5' 00"	0.0157
4 1/2	0.0057	0.0184	0.0006	0.0005	5' 00"	0.0172
4	0.0064	0.0204	0.0006	0.0005	5' 00"	0.0192

CLASS II-A, MEDIUM FIT (REGULAR)

This class is intended to apply to interchangeable manufacture where the threaded members are to be assembled nearly, or entirely, with the fingers, and where a moderate amount of shake or play between the assembled threaded members is not objectionable. This class includes the great bulk of fastening screws for instruments, small arms and other ordnance material such as gun carriages, aerial-bomb-dropping devices, and interchangeable accessories mounted on guns; also machine screws, cap screws, and screws for sewing machines, typewriters and other work of a similar nature.

The pitch diameter of the minimum nut of a given diameter and pitch corresponds to the basic pitch diameter as specified in tables of thread systems herein given and is computed from the basic major diameter of the thread to be manufactured. The major diameter and pitch diameter of the maximum screw of a given pitch and diameter correspond to the basic dimensions as specified in tables of thread systems herein given, which are computed from the basic major diameter of the thread to be manufactured.

The tolerance on the nut will be plus, applied from the basic size to above basic size; the tolerance on the screw will be minus, applied from the basic size to below basic size. The allowance between the size of the maximum screw and the minimum nut will be zero for all pitches and all diameters. The tolerance for a screw or nut of a given pitch will be as specified in Table 6.

CLASS II-B, MEDIUM FIT (SPECIAL)

This class is intended to apply especially to the higher grade of automobile screw-thread work. It is the same in every particular as Class II-A, Medium Fit (Regular), except that the tolerances are smaller. (Table 7.)

TABLE 6 CLASS II-A—MEDIUM FIT (REGULAR)
ALLOWANCES AND TOLERANCES
SCREWS, NUTS AND GAGES

1	2	3	4	5	6
		MASTER GAGE TOLERANCES			
No. Thds. per Inch	Extreme or Drawing Pitch Diam. Tolerances Inches	Diameter Inches	Lead (+ or −) Inches	1/2 Angle. (+ or −) Minutes	Net Pitch Diameter Tolerances Inches
80	0.0017	0.0002	0.0002	30' 00"	0.0013
72	0.0018	0.0002	0.0002	30' 00"	0.0014
64	0.0019	0.0002	0.0002	30' 00"	0.0015
56	0.0020	0.0002	0.0002	30' 00"	0.0016
48	0.0022	0.0002	0.0002	30' 00"	0.0018
44	0.0023	0.0002	0.0002	30' 00"	0.0019
40	0.0024	0.0002	0.0002	20' 00"	0.0020
36	0.0025	0.0002	0.0002	20' 00"	0.0023
32	0.0027	0.0002	0.0002	20' 00"	0.0025
28	0.0031	0.0003	0.0002	15' 00"	
24	0.0033	0.0003	0.0002	15' 00"	0.0027
20	0.0036	0.0003	0.0002	15' 00"	0.0030
18	0.0041	0.0004	0.0003	10' 00"	0.0033
16	0.0045	0.0004	0.0003	10' 00"	0.0037
14	0.0049	0.0004	0.0003	10' 00"	0.0041
13	0.0052	0.0004	0.0003	10' 00"	0.0044
12	0.0056	0.0004	0.0003	10' 00"	0.0048
11	0.0059	0.0003	0.0003	10' 00"	0.0051
10	0.0064	0.0004	0.0004	5' 00"	0.0056
9	0.0070	0.0004	0.0004	5' 00"	0.0062
8	0.0076	0.0004	0.0004	5' 00"	0.0068
7	0.0085	0.0004	0.0004	5' 00"	0.0077
6	0.0101	0.0006	0.0005	5' 00"	0.0089
5	0.0116	0.0006	0.0005	5' 00"	0.0104
4-1/2	0.0127	0.0006	0.0005	5' 00"	0.0115
4	0.0140	0.0006	0.0005	5' 00"	0.0128

Allowances, in all cases, = zero

TABLE 7 CLASS II-B—MEDIUM FIT (SPECIAL)
ALLOWANCES AND TOLERANCES
SCREWS, NUTS AND GAGES

1	2	3	4	5	6
		MASTER GAGE TOLERANCES			
No. Thds. per Inch	Extreme or Drawing Pitch Diam. Tolerances Inches	Diameter Inches	Lead (+ or −) Inches	1/2 Angle, (+ or −) Minutes	Net Pitch Diameter Tolerances, Inches
80	0.0013	0.0002	0.0002	30' 00"	0.0009
72	0.0013	0.0002	0.0002	30' 00"	0.0009
64	0.0014	0.0002	0.0002	30' 00"	0.0010
56	0.0015	0.0002	0.0002	30' 00"	0.0011
48	0.0016	0.0002	0.0002	30' 00"	0.0012
44	0.0016	0.0002	0.0002	30' 00"	0.0012
40	0.0017	0.0002	0.0002	20' 00"	0.0013
36	0.0018	0.0002	0.0002	20' 00"	0.0014
32	0.0019	0.0002	0.0002	20' 00"	0.0015
28	0.0022	0.0003	0.0002	15' 00"	0.0016
24	0.0024	0.0003	0.0002	15' 00"	0.0018
20	0.0026	0.0003	0.0002	15' 00"	0.0020
18	0.0030	0.0004	0.0003	10' 00"	0.0022
16	0.0032	0.0004	0.0003	10' 00"	0.0024
14	0.0036	0.0004	0.0003	10' 00"	0.0028
13	0.0037	0.0004	0.0003	10' 00"	0.0029
12	0.0040	0.0004	0.0003	10' 00"	0.0032
11	0.0042	0.0004	0.0003	10' 00"	0.0034
10	0.0045	0.0004	0.0004	5' 00"	0.0037
9	0.0049	0.0004	0.0004	5' 00"	0.0041
8	0.0054	0.0004	0.0004	5' 00"	0.0046
7	0.0059	0.0004	0.0004	5' 00"	0.0051
6	0.0071	0.0006	0.0005	5' 00"	0.0059
5	0.0082	0.0006	0.0005	5' 00"	0.0070
4 1/2	0.0089	0.0006	0.0005	5' 00"	0.0077
4	0.0097	0.0006	0.0005	5' 00"	0.0085

Allowances, in all cases, = zero

CLASS III, CLOSE FIT

This class is intended for threaded work of the finest commercial quality, where the thread has practically no backlash, and for light screwdriver fits. In the manufacture of screw-thread products belonging in this class, it will be necessary to use precision tools, selected master gages, and many other refinements. This quality of work should therefore be used only in cases where requirements of the mechanism being produced are exacting, or where special conditions require screws having a precision fit. In order to secure the fit desired, it may be necessary, in some cases, to select the parts when the product is being assembled.

The pitch diameter of the minimum nut of a given diameter and pitch will correspond to the basic pitch diameter as specified in tables of thread systems given herein, which is computed from the basic major diameter of the thread to be manufactured. The major diameter and pitch diameter of the maximum screw of a given diameter and pitch will be above the basic dimensions as specified in tables computed from the basic major diameter of the thread to be manufactured, by the amount of the allowance (interference) specified in Table 8.

The tolerance on the nut will be plus, applied from the basic size to above basic size; the tolerance on the screw will be minus, applied from the maximum screw dimensions to below the maximum screw dimensions. The allowance (interference) provided between the size of the minimum nut, which is basic, and the size of the maximum screw, which is above basic, and the tolerance for a screw or nut of a given pitch will be as specified in Table 8.

TABLE 8 CLASS III—CLOSE FIT
ALLOWANCES AND TOLERANCES
SCREWS, NUTS AND GAGES

1	2	3	4	5	6	7
No. Thds per Inch	Interference or Negative Allowances, Inches	Extreme or Drawing Pitch Diam. Tolerances, Inches	Master Gage Tolerances			Net Pitch Diameter Tolerances, Inches
			Diameter, Inches	Lead, (+ or −) Inches	1/2 Angle, (+ or −) Degrees	
80	0.0001	0.0006	0.0001	0.0001	15' 00"	0.0004
72	0.0001	0.0007	0.0001	0.0001	15' 00"	0.0005
64	0.0001	0.0007	0.0001	0.0001	15' 00"	0.0005
56	0.0002	0.0007	0.0001	0.0001	15' 00"	0.0005
48	0.0002	0.0008	0.0001	0.0001	15' 00"	0.0006
44	0.0002	0.0008	0.0001	0.0001	15' 00"	0.0006
40	0.0002	0.0009	0.0001	0.0001	10' 00"	0.0007
36	0.0002	0.0009	0.0001	0.0001	10' 00"	0.0007
32	0.0002	0.0010	0.0001	0.0001	10' 00"	0.0008
28	0.0002	0.0011	0.00015	0.0001	7' 30"	0.0008
24	0.0003	0.0012	0.00015	0.0001	7' 30"	0.0009
20	0.0003	0.0013	0.00015	0.0001	7' 30"	0.0010
18	0.0003	0.0015	0.0002	0.00015	5' 00"	0.0011
16	0.0004	0.0016	0.0002	0.00015	5' 00"	0.0012
14	0.0004	0.0018	0.0002	0.00015	5' 00"	0.0014
13	0.0004	0.0019	0.0002	0.00015	5' 00"	0.0015
12	0.0005	0.0020	0.0002	0.00015	5' 00"	0.0016
11	0.0005	0.0021	0.0002	0.00015	5' 00"	0.0017
10	0.0006	0.0023	0.0002	0.0002	2' 30"	0.0019
9	0.0006	0.0024	0.0002	0.0002	2' 30"	0.0020
8	0.0007	0.0027	0.0002	0.0002	2' 30"	0.0023
7	0.0008	0.0030	0.0002	0.0002	2' 30"	0.0026
6	0.0009	0.0036	0.0003	0.00025	2' 30"	0.0030
5	0.0010	0.0041	0.0003	0.00025	2' 30"	0.0035
4 1/2	0.0011	0.0044	0.0003	0.00025	2' 30"	0.0038
4	0.0013	0.0048	0.0003	0.00025	2' 30"	0.0042

CLASS IV, WRENCH FIT

This class is intended to cover the manufacture of threaded parts ¼ in. in diameter or larger which are to be set or assembled permanently with a wrench. Inasmuch as for wrench fits the material is an important factor in determining the fit between the threaded members, there are provided herein two subdivisions for this class of work, namely, A and B. These two subdivisions differ mainly in the amount of the allowance (interference) values provided for different pitches.

Subdivision A of Class IV, Wrench Fit, provides for the production of interchangeable wrench-fit screws or studs used in light sections with moderate stresses, such as for aircraft and automobile-engine work.

Subdivision B of Class IV, Wrench Fit, provides for the production of interchangeable wrench-fit screws or studs used in heavy sections with heavy stresses, such as for steam-engine and heavy hydraulic work.

The pitch diameter of the minimum nut of a given diameter and pitch for threads belonging in either subdivision A or subdivision B will correspond to the basic pitch diameter as specified in tables of thread systems given herein, which is computed from the basic major diameter of the thread to be manufactured. The major diameter and pitch diameter of the maximum screw of a given diameter and pitch for threads belonging in either subdivision A or subdivision B will be above the basic dimensions as specified in tables of thread systems given herein, which are computed from the basic major diameter of the thread to be manufactured, by the amount of the allowance (interference) provided.

The tolerance on the nut will be plus, to be applied from the basic size to above basic size; the tolerance on the screw will be minus, to be applied from the maximum screw dimensions to below maximum screw dimensions. At the present time [when this report was released] the Commission does not have sufficient information or data to include the values for tolerances and allowances for wrench fits. It is hoped, however, that sufficient information resulting from investigation and research will enable the Commission to decide, at an early date, the allowance and tolerance values for these two classes of wrench fits included herein, which will be applicable to the various materials and which will meet the requirements found in the manufacture of machines or products requiring wrench fits.

TOLERANCES

There are specified herein, for use in connection with the various fits established, three different sets of tolerances (as given in Tables 5, 6, 7, and 8), which represent the extreme variations allowed on the work.

The tolerance limits established represent in reality the sizes of the "Go" and "Not Go" master gages. Errors in lead and angle which occur on the threaded work can be offset by a suitable alteration of the pitch diameter of the work. If the "Go" gage passes the threaded work, interchangeability is secured and the thread profile may differ from that of the "Go" gage in either pitch diameter, lead or angle. The "Not Go" gage checks pitch diameter only and thus insures that the pitch diameter is such that the fit will not be too loose.

The tolerances established for Class I, Loose Fit, and Class II, Medium Fit, permit the use of commercial taps now obtainable from various manufacturers. For Class III, Close Fit, in which it is desired to produce a hole close to the basic size, it is recommended that a selected tap be used.

The pitch-diameter tolerances provided for a screw of a given class of fit will be the same as the pitch-diameter tolerances provided for a nut corresponding to the same class of fit.

The allowable tolerances on the major diameter of screws of a given classification will be twice the tolerance values allowed on the pitch diameters of screws of the same class.

The minimum minor diameter of a screw of a given pitch will be such as to result in a basic flat ($= \frac{1}{8}p$) at the root when the pitch diameter of the screw is at its minimum value. When the maximum screw is basic, the minimum minor diameter of the screw will be below the basic minor diameter by the amount of the specified pitch-diameter tolerance.

The maximum minor diameter may be such as results from the use of a worn or rounded threading tool, when the pitch diameter is at its maximum value. In no case, however, should the form of the screw, as results from tool wear, be such as to cause the screw to be rejected on the maximum minor diameter by a "Go" ring gage, the minor diameter of which is equal to the minimum minor diameter of the nut.

Attention is called to the fact that the minimum threaded hole or nut corresponds to the basic size; that is, the minimum nut is basic for all classes of fit. This condition permits the use of taps which when new are oversize and which are discarded when the hole cut is at the basic size.

In order to secure the desired fit the screw size is varied; the maximum screw corresponds to the basic size for the medium-fit class, is slightly above basic size for the loose-fit class. The tolerances specified in column 7 of Tables 5 and 8, and column 6 of Tables 6 and 7, are the net tolerances which are in no way reduced by permissible manufacturing tolerances provided for by master gages. These master-gage tolerances are provided for by being added to the net tolerances. Thus the extreme or drawing tolerances are the net working tolerances increased by the master-gage increment of equivalent diametrical space required to provide for the master-gage tolerances. The limits established for the extreme tolerances should in no case be exceeded. The

application of gage tolerances in relation to tolerances allowed on the work can be best understood by considering that the extreme tolerances represent the absolute limits over which variations of the work must not pass. The manufacturing tolerances required for master gages are then deducted from the extreme working tolerances, producing the figures specified as net tolerances. Further reduction of the extreme tolerances is caused by the manufacturing tolerances required for the inspection gages and working gages.

It is essential that the proportion of the tolerances used by the workmen producing the work at the machine be well within the net tolerance limits. The net tolerance limits as established by the master gages may be considered as the largest circle of a target, the space occupied by the master-gage tolerances representing the width of the line establishing the largest circle. The marksman always aims to hit the bull's-eye. Any mark inside of the largest circle or cutting the circle scores. Any mark outside of the largest circle does not score. The same is true in producing work—the careful manufacturer will aim to produce work which is in the center of tolerance limits. The bull's-eye in this case, which is the working tolerance used at the machine, will be considerably less than the net tolerance and the result will be that a very large percentage of the work will be accepted, and spoiled or rejected work will be reduced to practically nothing. If the net tolerance limits are used as working limits at the machine, there will be a larger percentage of rejections due to differences in gages and wear of both tools and gages.

GAGES

The following general specifications which refer in particular to gaging systems which have been found satisfactory by the army and navy for the production of interchangeable parts are built upon the following assumptions:

a Approved limit master gages do not reduce the net working tolerance.

b Permissible errors in angle of thread specified for "Go" gages tend to reduce the net working tolerance, while similar permissible errors on the "Not Go" gage tend to increase the net working tolerance. These two factors, therefore, balance each other.

c Permissible lead errors specified for the "Go" gage reduce the net working tolerance, while permissible lead errors on the "Not Go" gage tend to increase the net working tolerance.

d In order to realize the full net working tolerance, the permissible diametrical variation specified for both "Go" and "Not Go" gages (gage increment) is placed outside of the net tolerance limits. The extreme tolerance equals the net tolerance plus gage increment.

e The "Go" gage should check simultaneously all elements of the thread (all diameters, lead, angle, etc.).

f The "Not Go" gage should check separately the elements of the thread.

General Specifications

The following specifications are included for the use of manufacturers where definite information is lacking but are not to be considered mandatory:

Classification: Thread gages may be included in one of four classes, namely, Standard Master Gages, Limit Master Gages, Inspection Gages, and Working Gages.

Standard Master Gage: The standard master gage is a threaded plug representing as exactly as possible all physical dimensions of the nominal or basic size of the threaded component. In order that the standard master gage be authentic, the deviations of this gage from the exact standard should be ascertained by the National Bureau of Standards, and the gage should be used with knowledge of these deviations or corrections.

Limit Master Gages: Limit master gages are for reference only. They represent the extreme upper and lower tolerance limits allowed on the dimensions of the part being produced. They are often of the same design as inspection gages. In many cases, however, the design of the master gage is that of a check which can be used to verify the inspection or working gage.

Inspection Gages: Inspection gages are for the use of the purchaser in accepting the product. They are generally of the same design as the working gages and the dimensions are such that they represent nearly the net tolerance limits on the parts being produced. Inasmuch as a certain amount of wear must be provided on an inspection gage, it cannot represent the net tolerance limit until it is worn to master-gage size.

Working Gages: Working gages are those used by the manufacturer to check the parts produced as they are machined. It is recommended that the working gages be made to represent limits considerably inside of the net limits in order that sufficient wear will be provided for the working gages, and in order that the product accepted by the working gages will be accepted by the inspection gages.

Inspection and Working-Gage Sets

For Screws: The following list enumerates the inspection and working gages required for producing strictly interchangeable screws as specified for National Coarse Threads, National Fine Threads, or other straight threads:

a A maximum or "Go" ring thread gage, preferably adjustable, having the required pitch diameter and minor diameter. The major diameter may be cleared to facilitate grinding and lapping.

b A minimum or "Not Go" ring thread gage, preferably adjustable, to check only the pitch diameter of the threaded work.

c A maximum or "Go" plain ring gage to check the major diameter of the threaded work.

d A minimum or "Not go" snap gage to check the major diameter of the threaded work.

For Nuts: The following list enumerates the inspection and working gages required for producing strictly interchangeable nuts, as specified for National Coarse Threads, National Fine Threads, or other straight threads.

a A minimum or "Go" thread plug gage of the required pitch diameter and major diameter. The minor diameter of the thread plug gage may be cleared to facilitate grinding and lapping.

b A maximum or "Not Go" thread plug gage to check only the pitch diameter of the threaded work.

c A "Go" plain plug gage to check the minor diameter of the threaded work.

d A "Not Go" plain plug gage to check the minor diameter of the threaded work.

Limit Master Gages Required for Checking Working or Inspection Gages

Used on Screw: The following list enumerates the limit master gages required for the verification of the working or inspection gages as previously listed for verifying the screw:

a A set plug or check for the maximum "Go" thread ring gage, having the same dimensions as the largest permissible screw.

b A set plug or check for the minimum or "Not Go" thread ring gage having same dimensions as smallest permissible screw.

c A maximum plain plug for checking the minor diameter of both the "Go" and "Not Go" inspection thread ring gage.

Used on Nut: The following list enumerates the limit master gages required for the verification of the working or inspection gages as previously listed for verifying the nut:

a A minimum or "Go" threaded plug to be used as a reference for comparative measurements and corresponds to the basic dimension, or standard master gage.

b A maximum or "Not Go" threaded plug to be used as a reference for comparative measurements and corresponds to the largest permissible threaded hole.

c A minimum plain ring gage to check the major diameter of the "Go" and "Not Go" master threaded plug unless suitable measuring facilities are available for this purpose.

Design and Construction

The following specification will be helpful in the design and construction of gages used for producing threaded work:

Material: Gages may be made of a good grade of machinery steel pack-hardened, or of straight carbon steel of not less than 1 per cent carbon; or preferably of an oil hardening steel of approximately 1.10 per cent carbon and 1.40 per cent chromium.

Handles and Marking: Handles should be made of a good grade of machinery steel plainly marked to identify the gage.

Plain Plug Gages: All plain plug gages should be single-ended. Plain plug gages of 2 in. and less in diameter should be made with a plug inserted in the handle and fastened thereto by means of a pin. Plain plug gages of more than 2 in. in diameter should have the gaging blank so made as to be reversible. This can be accomplished by having a finished hole in the gage blank fitting a shouldered projection on the end of the handle, the gage blank being held on with a nut.

The "Go" plain plug gage should be noticeably longer than the "Not Go" plain plug gage, or some distinguishing feature in the design of the handle should be used to serve as a ready means of identification, such as a chamfer on the handle of the "Go" gage.

Plain Ring Gages: Both the "Go" and "Not Go" gages should have their outside diameters knurled if made circular.

The "Go" gage should have a decided chamfer in order to provide a ready means of identification for distinguishing the "Go" from the "Not Go" gage.

Snap Gages: Snap gages may be either adjustable or non-adjustable. It is recommended that all snap gages up to and including 1/8 in. be of the built-up type. For larger snap gages, forge blanks, flat plate stock or other suitable construction may be used.

Sufficient clearance beyond the mouth of the gage should be provided to permit the gaging of cylindrical work.

Snap gages for measuring lengths and diameters may have one gaging dimension only, or may have a maximum and minimum gaging dimension, both on one end, or maximum and minmum gaging dimensions on opposite ends of the gage. When the maximum and minimum gaging dimensions are placed on opposite ends of the gage, the maximum or "Go" end of the snap gage will be distinguished from the minimum or "Not Go" end by having the corners of the gage on the "Go" end decidedly chamfered.

Plug Thread Gages: All plug thread gages should be single-ended. Thread plug gages 2 in. and less in diameter should be made with a plug inserted in a handle and fastened thereto by means of a pin.

Plug gages of more than 2 in. in diameter, unless otherwise specified, should have the gaging blank so made as to be reversible. This can be accomplished by having the finished hole in the gage blank fitting a shouldered projection on the end of the handle, the gage blank being keyed on and held with a nut.

"Not Go" thread plug gages should be noticeably shorter than the "Go" thread plug gages, in order to provide a ready means of identification, or the handle of the "Go" gage should be chamfered.

End threads on plug thread gages should not be chamfered, but the first half-turn of the end thread should be flattened to avoid a feather edge.

Inspection and working thread plug gages should be provided with dirt grooves which extend into the gage for a depth of from one to four threads.

The length of thread (L) parallel to the axis of the gage should, for all standard "Go" thread plug gages, be at least as much as the quantity expressed in the formula: $L = 1.5D$, where D is the basic major diameter of the thread. For threaded work of shorter length of engagement than $1.5D$, the length of thread on the "Go" gage may be correspondingly shorter.

"Not Go" Thread Gage for Pitch Diameter Only: All "Not Go" thread plug gages should be made to check the pitch diameter only. This necessitates removal of the crest of the thread so that the dimension of the major diameter is never greater than that specified for the "Go" gage, and also removing the portion of the thread at the root of the standard thread form.

Ring Thread Gages: All ring thread gages should be made adjustable.

The "Go" gage should be distinguished from the "Not Go" gage by having a decided chamfer and both gages are to have their outside diameter knurled if made circular.

The end threads on ring thread gages should not be chamfered but the first half turn of the end thread should be flattened to avoid a feather edge.

Length of Thread: The length of thread parallel to the axis of the gage should, for all standard "Go" ring thread gages, be at least as great as the quantity determined in the formula, $L = 1.5D$. For threaded work of shorter length of engagement than $1.5D$, the length of thread on the "Go" gage may be correspondingly shorter.

"Not Go" Ring Gage for Pitch Diameter Only: "Not Go" ring thread gages should be made to check the pitch diameter only. This necessitates removal of the crest of the thread so that the dimension of the minor diameter is never less than that specified for the maximum or "Go" gage, and also removing the portion of the thread at the root of the standard form.

Tolerances

There are specified herein for use in the production of National Coarse Threads, National Fine Threads, National Hose Coupling Threads and for other straight threads, and for National Pipe Threads, several tables of gage manufacturing tolerances.

Table 9 will be found practicable for all plain plug, ring and snap gages used in connection with a measurement of screw-thread diameters. In addition to the master-gage tolerances, suggested tolerances for inspection and working gages are also given.

TABLE 9 MANUFACTURING TOLERANCES ON PLAIN GAGES

Manufacturing Tolerance allowed on Work	Allowable Tolerance for Master Gages		Allowable Tolerance for Inspection Gages		Suggested Tolerance for Working Gages	
	Minimum Gage (+)	Maximum Gage (−)	Minimum Gage (+)	Maximum Gage (−)	Minimum Gage (+)	Maximum Gage (−)
0.002	0.0000	0.0000	0.0001	0.0001	0.0003	0.0003
	0.0001	0.0001	0.0003	0.0003	0.0005	0.0005
0.002 to 0.004	0.0000	0.0000	0.0002	0.0002	0.0004	0.0004
	0.0002	0.0002	0.0004	0.0004	0.0007	0.0007
0.004 to 0.006	0.0000	0.0000	0.0004	0.0004	0.0007	0.0007
	0.0003	0.0003	0.0007	0.0007	0.0011	0.0011
0.006 to 0.010	0.0000	0.0000	0.0006	0.0006	0.0010	0.0010
	0.0004	0.0004	0.0010	0.0010	0.0015	0.0015
0.010 to 0.020	0.0000	0.0000	0.0010	0.0010	0.0015	0.0015
	0.0005	0.0005	0.0015	0.0015	0.0021	0.0021
0.020 to 0.030	0.0000	0.0000	0.0020	0.0020	0.0026	0.0026
	0.0006	0.0006	0.0026	0.0026	0.0033	0.0033

Table 10 will be found practicable for both standard and limit master thread gages for thread work designed in accordance with the manufacturing tolerances for Class I, Loose Fit and Class II, Medium Fit, made to Tables 5, 6 and 7.

Tables 11 and 12 contain suggested manufacturing tolerances for inspection thread gages with a small allowance for wear for use in quantity production of Class I, Loose Fit and Class II, Medium Fit thread work, made to 5, 6 and 7.

Table 13 contains the tolerances suggested for both standard and limit master thread gages for work designed in accordance with manufacturing tolerances for Class III, Close Fit thread work, made to Table 8. As the component tolerances for this class are relatively small, it is believed that the working gages will be required to be held within the gage tolerances shown in this table.

Application of Gage Tolerances

Tolerances for Plain Gages: For plain plug gages, plain ring gages and plain snap gages required for measuring diameters of screw-thread work, the gage tolerances specified in Tables 10, 11, 12 and 13 should be used.

Attention is called to the fact that the tolerances on thread diameters vary in accordance with the number of threads per

inch on the screw or nut being manufactured. In manufacturing a plain plug, ring or snap gage, in absence of information as to the number of threads per inch of the screw to be made, or for gage dimension other than thread diameters, the tolerances for plain gages given in Table 10 may be used.

Tolerances on Lead: The tolerances on lead are specified as an allowable variation between any two threads not farther apart than the length of thread engagement as determined by the formula, $L = 1.5D$.

Tolerances on Angle of Thread: The tolerances on angle of thread as specified herein for the various pitches are tolerances on one-half of the inclined angle. This insures that the bisector of the included angle will be perpendicular to the axis of the thread within proper limits. The equivalent deviation from the true form caused by such irregularities as convex or concave sides of thread, rounded crests, or slight projections on the thread form, should not exceed the tolerances allowable on angle of thread.

TABLE 10 DIMENSIONS ON MASTER THREAD GAGES FOR LOOSE-FIT AND MEDIUM-FIT WORK

(This applies to both Standard and Limit Master Gages)

Number of Threads Per Inch	Allowable Variation in Lead between any two Threads not farther apart than Length of Engagement (+ or −)	Allowable Variation in one-half Angle of Thread Gages (+ or −)	Allowable Tolerances on Diameters of Minimum Thread Gages (+)	Allowable Tolerances on Diameters of Maximum Thread Gages (−)
4 to 6	0.0005	5′ 00″	0.0000 0.0006	0.0000 0.0006
7 to 10	0.0004	5′ 00″	0.0000 0.0004	0.0000 0.0004
11 to 18	0.0003	10′ 00″	0.0000 0.0004	0.0000 0.0004
20 to 28	0.0002	15′ 00″	0.0000 0.0003	0.0000 0.0003
30 to 40	0.0002	20′ 00″	0.0000 0.0002	0.0000 0.0002
44 to 80	0.0002	30′ 00″	0.0000 0.0002	0.0000 0.0002

TABLE 11 SUGGESTED MANUFACTURING TOLERANCES FOR INSPECTION GAGES FOR LOOSE-FIT AND MEDIUM-FIT WORK

Number of Threads per Inch	Allowable Variation in Lead between any two Threads not farther apart than Length of Engagement (+ or −)	Allowable Variation in one-half Angle of Thread Gages (+ or −)	Allowable Tolerances on Diameters of Minimum Thread Gages (+)	Allowable Tolerances on Diameters of Maximum Thread Gages (−)
4 to 6	0.0006	5′ 00″	0.0006 0.0015	0.0006 0.0015
7 to 10	0.0005	10′ 00″	0.0004 0.0010	0.0004 0.0010
11 to 18	0.0004	15′ 00″	0.0004 0.0008	0.0004 0.0008
20 to 28	0.0003	20′ 00″	0.0003 0.0006	0.0003 0.0006
30 to 40	0.0002	30′ 00″	0.0002 0.0005	0.0002 0.0005
44 to 80	0.0002	45′ 00″	0.0002 0.0004	0.0002 0.0004

Tolerances on Diameters: The tolerances given for thread diameters, in Tables 10, 11, 12 and 13, are applied in such a manner that the tolerances permitted on the inspection and working gages occupy part of the extreme tolerance. This insures that all work passed by the gages will be within the tolerance limits specified on the part drawing as represented by the limit master gages. The tolerances given also permit the classification and selection of gages so that if a gage is not suitable for a master gage it may be classified and used as an inspection or working gage provided that the errors do not pass outside of the net tolerance limits. The application of the tolerances on diameters of thread gages is exactly the same as explained herein for plain gages.

NATIONAL (AMERICAN) PIPE THREADS

The American Pipe Thread Standard, also known as the American (Briggs) Standard, was formulated by Mr. Robert Briggs, an American engineer, prior to 1882. After his death a paper containing detailed information of the system he devised was read before the Institution of Civil Engineers of Great Britain.[1] In 1886 representatives of various manufacturing concerns and a committee of The American Society of Mechanical Engineers jointly adopted this system in detail and master gages were made. This standard has since been used in the United States and Canada.

At various conferences in the recent past, representatives of American manufacturers and The American Society of Mechanical Engineers established additional sizes, certain details of gaging, tolerances, and special applications of the standard. These were tabulated in a much more complete manner than was originally done by Mr. Briggs, by a special committee known as the Committee of Manufacturers on the Standardization of Valves and Fittings, and published at the suggestion of The American Society of Mechanical Engineers, in October, 1919, under the title, A Manual on American Pipe Threads. This report contained the first mention of tolerances in connection with pipe threads. It was endorsed by the American Gas Association and later was adopted by the National Screw Thread Commission with only such changes as were necessary to bring it into conformity with the remainder of its report.—EDITOR.

TABLE 12 SUGGESTED MANUFACTURING TOLERANCES FOR WORKING GAGES FOR LOOSE-FIT AND MEDIUM-FIT WORK

Number of Threads per Inch	Allowable Variation in Lead between any two Threads not farther apart than Length of Engagement (+ or −)	Allowable Variation in one-half Angle of Thread Gages (+ or −)	Allowable Tolerances on Diameters of Minimum Thread Gages (+)	Allowable Tolerances on Diameters of Maximum Thread Gages (−)
4 to 6	0.0006	5′ 00″	0.0015 0.0025	0.0015 0.0025
7 to 10	0.0005	10′ 00″	0.0010 0.0020	0.0010 0.0020
11 to 18	0.0004	15′ 00″	0.0008 0.0015	0.0008 0.0015
20 to 28	0.0003	20′ 00″	0.0006 0.0012	0.0006 0.0012
30 to 40	0.0002	30′ 00″	0.0005 0.0010	0.0005 0.0010
40 to 80	0.0002	45′ 00″	0.0004 0.0006	0.0004 0.0006

TABLE 13 MASTER GAGE TOLERANCES FOR CLASS III, CLOSE-FIT WORK

(This applies to both Standard and Limit Master Gages)

Number of Threads per Inch	Allowable Variation in Lead between any two Threads not farther apart than Length of Engagement (+ or −)	Allowable Variation in one-half Angle of Thread Gages (+ or −)	Allowable Tolerances on Diameters of Minimum Thread Gages (+)	Allowable Tolerances on Diameters of Maximum Thread Gages (−)
4 to 6	0.00025	2′ 30″	0.0000 0.0003	0.0000 0.0003
7 to 10	0.0002	2′ 30″	0.0000 0.0002	0.0000 0.0002
11 to 18	0.00015	5′ 00″	0.0000 0.0002	0.0000 0.0002
20 to 28	0.0001	7′ 30″	0.0000 0.00015	0.0000 0.00015
30 to 40	0.0001	10′ 00″	0.0000 0.0001	0.0000 0.0001
44 to 80	0.0001	15′ 00″	0.0000 0.0001	0.0000 0.0001

OUTLINE OF STANDARD

The National (American) Pipe Thread Standard establishes the following: Outside Diameter of Pipe; Diameter of External (Male) Thread; Diameter of Internal (Female) Thread; Profile of Thread; Pitch or Lead of Thread; Length of Thread; Taper of Thread; Engagement (by hand) of External and Internal Threads; Construction and Use of Gages; Tolerances; Use of Taper Threads; Use of Straight Threads.

The dimensions of National (American) Pipe Threads are expressed in inches to one-one hundred thousandth (0.00001) of an inch, and in millimeters to one-thousandth (0.001) of a millimeter.

While this is a greater degree of accuracy than is ordinarily

[1] Recorded in the Excerpt Minutes, vol. LXXI, sessions of 1882-1883, part 3.

used, the dimensions are so expressed in order to eliminate errors which might result from less accurate dimensions. The relation between the inch and the meter used in calculating the dimensions in the tables is that established by law in the United States and on record in the Bureau of Standards, Department of Commerce, Washington, D. C., viz.,

1 meter = 39.37 inches, exactly
25.40005 millimeters = 1 inch.

SPECIFICATIONS OF THREAD

The standard outside diameter of pipe is given in Column G of Table 14 of dimensions. These diameters should be very closely adhered to by pipe manufacturers.

The pitch diameters of the taper thread are determined by formulæ based on the outside diameter of pipe and the pitch of thread. These are as follows:

$$A = G - (0.05G + 1.1)P$$
$$B = A + 0.0625F$$

in which

A = Pitch diameter of thread at end of pipe
B = Pitch diameter of thread at gaging notch
G = Outside diameter of pipe
F = Normal engagement by hand between external and internal threads
P = Pitch of thread.

The angle between the sides of the thread is 60 deg. when measured in the axial plane, and the line bisecting this angle is perpendicular to the pipe axis for taper or straight threads.

The crest and root are truncated an amount equal to 0.033 P. The depth of the thread, therefore, is 0.8 P.

The length of the taper external thread is determined by a formula based on the outside diameter of pipe and the pitch of the thread. This is as follows[4]:

$$E = (0.8G + 6.8)P$$

where

E = Length of effective thread
G = Outside diameter of pipe
P = Pitch of thread.

The taper of the thread is 1 in 16, measured on the diameter. The normal length of engagement between taper external and internal threads when screwed together by hand is shown in column F, Table 14. This length is controlled by the construction and use of the gages.

In these specifications the lead of the screw is expressed in terms of the number of threads in one inch and the number of threads in 254 millimeters (10 in.).

[4] The above formulæ are not expressed in the same terms as the formulæ originally established by Mr. Briggs; however, both forms give identical results.

TABLE 14—DIMENSIONS OF NATIONAL (AMERICAN) PIPE THREADS

Nominal Size		A		B		E		F		G		Depth of Thread		Number of Threads	
Inches	M.M.	Inches	M.M	Inches	M.M	Inches	M.M	Inches	M.M.	Inches	M.M.	Inches	M.M.	Per Inch	Per 254 M.M.
1/8	3	36351	9.233	.37476	9.519	2638	6.700	.180	4.572	405	10.287	02963	.753	27	270
1/4	6	.47739	12.126	.48989	12.443	4018	10.206	200	5.080	540	13.716	.04444	1 129	18	180
3/8	10	.61201	15.545	.62701	15.926	4078	10.358	.240	6.096	.675	17.145	.04444	1 129	18	180
1/2	13	.75843	19.264	.77843	19.772	.5337	13.556	.320	8 128	.840	21.336	.05714	1.451	14	140
3/4	19	.96768	24.579	.98886	25 117	5457	13.861	.339	8.611	1.050	26.670	.05714	1.451	14	140
1	25	1.21363	30.826	1.23863	31.461	.6828	17.343	.400	10 160	1.315	33.401	.06956	1.767	11½	115
1¼	32	1.55713	39.551	1 58338	40.218	7068	17.953	420	10.668	1.660	42.164	.06956	1 767	11½	115
1½	38	1.79609	45.621	1.82234	46.287	.7235	18.377	420	10.668	1.900	48.260	.06956	1.767	11½	115
2	50	2.26902	57.633	2.29627	58.325	7565	19.215	436	11.074	2.375	60.325	06956	1 767	11½	115
2½	64	2.71953	69.076	2.76216	70.159	1.1375	28.892	682	17.323	2.875	73.025	.10000	2.540	8	80
3	76	3.34063	84.852	3.38850	86.068	1 2000	30.480	766	19 456	3.500	88.900	.10000	2 540	8	80
3½	90	3.83750	97 473	3.88881	98.776	1 2500	31.750	.821	20.853	4.000	101.600	.10000	2 540	8	80
4	100	4.33438	110.093	4.38713	111.433	1.3000	33.020	.844	21.438	4.500	114.300	.10000	2 540	8	80
4½	113	4.83125	122.714	4.88594	124.103	1.3500	34.290	.875	22.225	5.000	127.000	.10000	2.540	8	80
5	125	5.39073	136.925	5.44929	138.412	1.4063	35.720	.937	23.800	5 563	141.300	.10000	2.540	8	80
6	150	6.44609	163.731	6.50597	165.252	1.5125	38.417	958	24.333	6.625	168.275	.10000	2.540	8	80
7	175	7.43984	188.972	7.50234	190.560	1 6125	40.957	1.000	25.400	7.625	193.675	.10000	2.540	8	80
8	200	8.43359	214.214	8.50003	215.901	1 7125	43.497	1.063	27.000	8.625	219.075	.10000	2.540	8	80
9	225	9.42734	239.455	9 49797	241.249	1.8125	46.037	1.130	28.702	9.625	244.475	.10000	2.540	8	80
10	250	10.54531	267.851	10 62094	269.772	1.9250	48.895	1 210	30.734	10 750	273 050	.10000	2.540	8	80
11	275	11.53906	293.093	11.61938	295.133	2.0250	51.435	1 285	32.639	11.750	298.450	.10000	2.540	8	80
12	300	12.53281	318.334	12.61781	320.493	2 1250	53 975	1 360	34.544	12.750	323.851	.10000	2.540	8	80
14 O.D.	350	13.77500	349.886	13 87262	352.365	2 250	57 150	1.562	39.675	14.000	355.601	.10000	2.540	8	80
15 O.D.	375	14.76875	375.127	14.87419	377.805	2.350	59.690	1.687	42.850	15.000	381.001	.10000	2.540	8	80
16 O.D.	400	15.76250	400.368	15.87575	403.245	2.450	62 230	1.812	46.025	16.000	406 401	.10000	2.540	8	80
17 O.D.	425	16.75625	425.609	16 87500	428.626	2 550	64.770	1.900	48.260	17.000	431.801	.10000	2.540	8	80
18 O.D.	450	17.75000	450.851	17.87500	454.026	2.650	67.310	2.000	50.800	18.000	457.201	.10000	2.540	8	80
20 O.D.	500	19.73750	501.333	19.87031	504.707	2.850	72.390	2.125	53.975	20.000	508.001	.10000	2.540	8	80
22 O.D.	550	21.72500	551.816	21.86562	555.388	3.050	77.470	2.250	57.150	22.000	558.801	.10000	2.540	8	80
24 O.D.	600	23.71250	602.299	23.86094	606.069	3 250	82.550	2.375	60.325	24.000	609.601	.10000	2.540	8	80
26 O.D.	650	25.70000	652.781	25.85625	656.750	3.450	87.630	2.500	63.500	26.000	660.401	.10000	2.540	8	80
28 O.D.	700	27.68750	703.264	27.85156	707.431	3.650	92 710	2.625	66.675	28.000	711 201	.10000	2.540	8	80
30 O.D.	750	29.67500	753.746	29.84687	758.112	3.850	97.790	2.750	69.850	30.000	762.001	.10000	2 540	8	80

TYPICAL SPECIFICATIONS FOR SCREW-THREAD PRODUCTS

Material: The material used shall be cold-drawn Bessemer Steel Automatic Screw Stock.

Composition:

Carbon, 0.08 to 0.16 per cent
Manganese, 0.50 to 0.80 per cent
Phosphorus, 0.09 to 0.13 per cent
Sulphur, 0.075 to 0.13 per cent.

Method of Manufacture: Bolts and nuts may be either rolled, milled, or machine-cut, so long as they meet the provided specifications, and are to be left soft.

Workmanship: All bolts and nuts must be of good workmanship and free from all defects which may affect their serviceability.

Finish: All bolts and nuts shall be semi-finished; that is, the bodies are to be machined, under side of head and nut faced, and upper face of head and nut chamfered at an angle of 30 deg., leaving a circle equal in diameter to the width of the nut.

Form of Thread: The form of thread shall be the "National Form," as specified herein, and formerly known as the United States Standard or Sellers Thread.

Thread Series: The pitches and diameters shall be as specified in Table 1, and known as the National Coarse Thread Series.

Class of Fit: Class II-A, Medium Fit (Regular).
Dimensions:
- *a* Nominal Size: ½ in.
- *b* Number of Threads Per Inch: 13.
- *c* Length Under Head: 3 in. ± 0.05 in.
- *d* Minimum Length of Usable Thread: 1 in.
- *e* Diameters: See Table XI, in complete report.

Tolerances and Allowances: See Table 6.
Nuts:
- *a* Form: Hexagonal.
- *b* Thickness: ½ in. ± 0.01 in.
- *c* Short Diameter (Across Flats): ⅞ in. ± 0.01.

Heads:
- *a* Form: Hexagonal
- *b* Thickness: 7/16 in. ± 0.01 in.
- *c* Short Diameter (Across Flats): ⅞ in. ± 0.01 in.

Gages: The gages used shall be such as to insure that the product falls within the tolerances as specified herein for Class II, Medium Fit (Regular).

The following gages are suggested and will be used by the purchaser:

For the Screw:
- *a* A maximum or "Go" ring thread gage
- *b* A minimum or "Not Go" ring thread gage to check only the pitch diameter.
- *c* A maximum or "Go" plain ring to check the major diameter.
- *d* A minimum or "Not Go" snap gage to check the major diameter

For the Nut:
- *a* A minimum or "Go" thread plug gage
- *b* A maximum or "Not Go" thread plug gage to check only the pitch diameter
- *c* A "Go" plain plug gage to check the minor diameter
- *d* A "Not Go" plain plug gage to check the minor diameter of the thread.

Inspection and Test: Screws and nuts shall be inspected and tested as follows:

At least three bolts and nuts shall be taken at random from each lot of 100, or fraction thereof, and carefully tested. If the errors in dimensions of the screws or nuts tested exceed the tolerance specified for this class, the lot represented by these samples shall be rejected.

Delivery: Unless otherwise specified the assembled bolts and nuts are to be delivered in substantial wooden containers, properly marked, and each containing 100 lb.

FUTURE WORK OF COMMISSION

The problems of standardization so far considered by the Commission have been those of most pressing importance to manufacturers and users of screw-thread products.

It is the intention of the Commission to continue the work of gathering information in regard to special problems still to be considered. The following list includes the more important screw threads which require standardization:
- *a* Threads cut on brass tubing
- *b* Instrument threads
- *c* Acme, square, buttress and other special threads.

In addition to the standardization of various thread systems, the Commission believes that it would be of great advantage to American manufacturers to have established standards for stock, tools and other appliances used in the production of screw threads, such as the following:
- *a* Taps
- *b* Dies
- *c* Sizes of bar stock for producing cut threads
- *d* Sizes of bar stock for producing rolled threads
- *e* Dimensions of bolt heads and nuts
- *f* Standardization of sheet-metal and wire-gage sizes
- *g* Standardization of tap-drill sizes.

The recent war has demonstrated the need of interchangeability of articles manufactured in this country with those manufactured abroad and it is known that manufacturers and authorities of Great Britain, France, and other foreign countries are awake to the situation and, in fact, have already taken steps toward the international standardization of screw threads and other manufactured articles. Furthermore, international standardization is of great importance in connection with the development of foreign trade.

In July, 1919, the Commission sent to Europe a delegation of its members to confer with British and French engineering standards organizations, and while no definite agreements were reached in regard to international standardization of screw threads, it was apparent in both France and England that the engineers and manufacturers in these countries are anxious to coöperate with the United States in this work. The time is very opportune for accomplishments along this line, and it is the opinion of the Commission that, as a result of the war, it should in time be possible to reach an agreement on an international standard thread. Such an international standard should be established by giving consideration to the predominating sizes and standards used in manufactured products, as well as to the possibilities of providing a means for producing this international screw thread by the use of either the English or the Metric system of measurement.

Opposed-Piston Diesel Engine

A type of marine Diesel oil engine operating on the opposed-piston principle, recently developed by Messrs. Cammell Laird and Co., of Birkenhead, England, has been described in various periodicals, notably London *Engineering* of Jan. 30, 1920. The chief advantage claimed for it is that its weight, and therefore its cost, for a given power is lower than with any existing type, while the space occupied is smaller. Each unit comprises two parallel cylinders in each of which are two opposed pistons. The usual three cranks between the main bearings in the opposed-piston engine have been reduced to two by cross-connecting the top pistons to the crossheads attached to the adjacent bottom pistons. This arrangement, which is a characteristic feature of the engine, relieves the framing of most of its stresses except those imposed by the oblique rods extending from the upper pistons and enables a lighter framing to be employed than with ordinary motors. Each unit is equal in effect to a single-cylinder double-acting engine and the same effect is obtained with two connecting rods, two cranks, two cylinders and four pistons, as would require two cylinders, four pistons, six connecting rods, and six cranks with the ordinary opposed-piston type of engine.

In other respects the lines of the ordinary opposed-piston design have been followed. The fuel is injected by means of a centrally placed fuel valve, just before the pistons reach their nearest central point, the combustion chamber being thus formed between the faces of the two pistons. At the bottom of the cylinder are arranged ports around the circumference through which scavenging air is admitted when these ports are uncovered by a bottom piston in the course of its stroke. Exhaust takes place through a similar series of ports at the top of the cylinder, these being uncovered in their turn by the upper piston just before the end of its stroke. The scavenging air thus passes through the whole cylinder and a very good scavenging effect is obtained, giving the engine a high efficiency for a two-cycle type, the fuel consumption being 0.42 pound per brake horsepower hour. The scavenging pumps are of simple design. The air supply, both for the injection of the fuel and for starting purposes, is obtained from a three-stage vertical air compressor driven by the engine. The pumps for the circulating water and lubricating oil are driven from eccentrics. The engine is to be built in standard sizes of 1000 hp. for installation in single or twin screw cargo ships.

In view of the small space occupied by this engine, it is stated that the steam engine and boilers can be taken out of existing steamships and replaced by an engine of this type without altering the shafting or propellers. The low speed of revolution consequent upon the adoption of opposed pistons—the piston speed at 110 r.p.m. is only some 450 ft. per min., or equivalent in effect to 900 ft. per min.—makes this possible.

The Financial Problems of Industrial Housing

By LESLIE H. ALLEN,[1] SPRINGFIELD, MASS.

This paper treats industrial housing as a financial problem. Our housing shortage is said to be due partly to the fear of a financial panic and partly to the fact that, high as rents are, they are not high enough to show an adequate return on present-day construction costs. The relation of rents to capital invested, the calculation of proper rents, and methods of financing house construction are discussed in some detail. The financial difficulties which face those desiring to purchase new homes are also taken up and selling plans that will meet the purchasers' needs and their ability to pay are outlined. The paper closes with a discussion of the scheme of coöperative housing, which the author suggests may be the solution of America's housing problems.

The close of the year 1919 finds our industrial housing problem still unsolved. The expected fall in prices has not come and does not seem likely to come. The speculative builder seems to be definitely out of the field. Rents are still rising but have not risen high enough to show a proper return on present-day construction costs. The shortage of materials and freight cars has caused a notable increase in building costs during the past few months, so that today a house will cost 35 per cent more than it did last November. Some employers who built houses last year are using these as an inducement to attract help from other localities. Those who did not build are coming to the conclusion that they cannot hold their help without building this year, and in the meantime their production and sales are falling off because they are short of help.

Manufacturers are still hesitating and doubting the wisdom of starting their housing programs because of the fear of a financial panic or a period of depression and fall in prices. They persist in ignoring the presence of our Federal Reserve Bank which was created for the very purpose of stabilizing our financial situation. They also ignore the fact that organized labor is demanding a larger share of the returns from industry than it has received before and is going to see that it gets it.

Present Renting Difficulties

The second difficulty is that the employer thinks he cannot rent his new house at a figure that will show an adequate financial return. It is unfortunate that the unattractiveness of the house as an investment is due to the fact that receipts from rent are usually not enough to pay a fair interest and allow for depreciation.

The rents charged were fixed many years ago; the manufacturer has not ventured to raise them to correspond with rising costs or increased wages, because of the odium that attaches to such action when the employer is also the landlord. In consequence, we find that most mills are not receiving enough rents to take care of the cost of maintenance and taxes. These low rents aggravate the housing shortage because they influence rentals and real-estate values all through the town. Other parties may get slightly higher rents, but not enough more to make property owning an attractive investment, and this discourages them even in normal times and is now an absolute barrier to real-estate development by others.

Calculation of Proper Rent

At this point it may be well to discuss what is a proper rent for a house. Assuming a lot and a house built today cost $6000, of which $500 is the cost of the lot and $5500 the cost of the house, the annual charges to be covered by rent would be as follows:

The prevailing interest on first mortgages is 6 per cent. Taxes vary according to locality, but a total charge of $100 will probably cover taxes, insurance and water.

At the end of twenty years the house, even after renewing the roof, heater and plumbing, will not be worth as much as its original cost. It will have depreciated through wear and tear at least 30 per cent on the first cost, the figure varying according to the quality of material and workmanship in the building and the amount of care taken of the premises by the tenant. If we assume in this case an average of 30 per cent on $4000 (the cost of the structure above the cellar) we obtain $1200 or a charge of $60 per annum. A tabulation of these charges worked out on an annual basis follows:

Outside painting	$100 ÷ 3	$ 33.33
Inside painting	140 ÷ 7	20.00
Roofing	100 ÷ 20	5.00
Heater	150 ÷ 20	7.50
Plumbing	350 ÷ 20	17.50
General Repairs	Average	15.00
Depreciation, at 2 per cent, on remainder of superstructure		60.00
Total maintenance and depreciation		158.33
Taxes and insurance		100.00
Interest on investment		360.00
Total		$618.33

This figure, amounting to slightly over 10 per cent on the investment, does not allow anything for management. It is equal to a rent of $51.50 per month and is as low as it is safe to figure with favorable conditions. The calculations take no account of possible rise in land values or in cost of building materials which might offset depreciation.

Methods of Financing House Construction

The third big problem that confronts the employer in his housing problem is how to finance the large expenditure needed. The ultimate purchaser usually cannot make a large initial payment and his earnings do not permit very large monthly payments on the amount he borrows. It is very seldom that more than 10 per cent of the purchase price is offered as a first payment, and repayment of principal borrowed on mortgages is stretched out by employers over periods of from 10 to (in one case) 34 years.

In most of the plans now in use the employer has to take back a second mortgage for at least 40 per cent of the total cost.

The building and loan associations of America find themselves with insufficient funds available for home buying and home building because their only source of working capital is derived from weekly cash deposits paid in by the association members. To relieve these conditions the Federal Building Loan Act has been introduced in Congress to Encourage Home Ownership and to Stimulate the Buying and Building of Homes. These bills would create a system of Federal Building Loan Banks operating under the general supervision of the Treasury Department, and make available, for the purpose of dwelling construction, a considerable portion of the two billion dollars now tied up in the mortgages held by the building and loan associations throughout the country.

The combination of manufacturers into a local housing corporation which shows a willingness to take the risk of building houses has proved of considerable encouragement to the prospective home purchasers. The housing corporations also gain the advantage of economical purchasing and quantity production in the erection of houses.

There are many localities where united action by manufacturers is not possible and here the employer is advised to organize his own subsidiary realty company. It is unquestionably of benefit to him that he should not be both employer and landlord.

The suggestion has been made in several quarters that new house construction should be exempt from local taxation for a period of five or ten years. The benefits of this in communities where the housing shortage is very acute would at once be felt, as local taxation usually amounts to one-quarter of the rental

[1] With Fred T. Ley & Co., Inc.

Abstract of a paper presented at the Spring Meeting, St. Louis, Mo., May 24 to 27, 1920, of The American Society of Mechanical Engineers. Copies of the complete paper may be obtained upon application. All papers are subject to revision.

cost of a house. It is a method often used to attract new manufacturing industries to a town and precedent for such procedure is therefore established. It may be objected, however, that the building of a number of houses adds a far greater burden to a town's expenses than an expenditure of equal amount in factory construction, as the houses usually call for an expenditure on sewers, water, etc., out of a town's funds and an additional tax on the town's school facilities, fire-protection service, police, etc. The exemption from local taxation, therefore, can only be considered an emergency measure. It is not economically sound and should be used only as a means of making all classes of a community contribute toward the relief of a town's housing shortage where other methods of enlisting their support have failed.

There is a wide difference of opinion among employers as to the wisdom of renting or selling homes to employees. The rental of houses acts as a check on the tenant leaving the factory of the company who owns the house. Rental is further necessary for young married couples not in a position to buy. The selling of houses to the workman is of advantage because the married man in his own home makes a better workman, becomes a better citizen and acquires a permanent interest in the community. For the selling scheme to be satisfactory the purchaser must be guaranteed that his investment is a liquid one. The employer must be protected if values rise and if the employee leaves his employ before the house is entirely paid for. Various plans for determining the paid-in value of the house are used which insure fairness to the workman and the employer.

A selling plan that will meet the purchaser's needs and his ability to pay is of great importance. The ordinary workman does not understand the business of home ownership, so if the selling plan is to be a success most of the thinking and planning and financing must be arranged for him. The first payment may be as low as 2 per cent, but a man worthy to purchase a house should be able to put down at least 5 per cent. Interest charges are the large item in his annual carrying charges and these will be decreased by a large initial payment. The best plan is for the man to arrange a monthly payment to take care of all outgoings and amortization of the principal.

The following examples show various methods of financing the sale of a home. It is assumed that the purchaser is earning \$2500 a year, and should be able to pay about \$600 a year (or \$50 a month for carrying charges and amortization). In each case the price of the house and lot is assumed to be \$6000 and the amount of the first payment \$600, leaving \$5400 to be financed. Smaller or larger transactions can be figured pro rata.

The method of dealing with the mortgage finance corporations is to place a first mortgage for 50 or 60 per cent of the value and a second mortgage for the difference between that and the first payment. This would work out as follows:

First mortgage, \$3000 at 6 per cent	\$180
Second mortgage, \$2400 at 6 per cent, amortized in 12 years	288
Taxes, insurance and water	100
Minor repairs and painting (average)	30
Total (\$50 per month)	\$598

When the second mortgage is amortized the workman can clear off his first mortgage in about eight years more if he continues to pay in \$50 per month.

Where the purchaser's income is large enough a building and loan association mortgage for 75 or 80 per cent of the price can be taken out, and the difference between this and the first payment would have to be taken by a second mortgage. This would work out as follows:

Coöperative bank mortgage, \$4000 at 6 per cent	\$240
Coöperative bank dues to amortize mortgage in 12½ years	240
Second mortgage of \$1400 at 6 per cent amortized in 12 years	168
Taxes, insurance and water	100
Minor repairs and painting	30
Total (\$65 per month)	\$778

Under this method the property would be entirely paid for in 12½ years, but the monthly payments are so high that very few workmen are able to purchase in this way.

Some firms prefer to sell on a purchase agreement by which title does not pass until the house is paid for. The tenant gives a note or else land contract for the amount owing on this. He pays interest annually, and a certain minimum payment on principal, which he is encouraged to increase if possible. The advantage in this method is that a tenant is more likely to make extra efforts to pay off the principal because he sees his interest payments being reduced as often as he makes payments. In times of prosperity or high wages he can do this easily, whereas if hard times come he can reduce his annual payments to the specified minimum. The annual payments and maturity length would work out as follows:

First mortgage or purchase agreement at 6 per cent (amortized in 24 years)	\$432
Taxes, insurance and water	100
Minor repairs and painting	30
Total (\$47 per month)	\$562

Amortization of Mortgages

The rate of interest is such a big item in the annual cost of a house that some firms are charging less than market rates in order to help their men. One national concern is taking back a first mortgage of 95 per cent of the net cost at 4½ per cent, the principal being amortized in 30 years. At first sight it may seem that this is unbusinesslike, but the plan is undoubtedly a wise one that will benefit both parties to the deal. The difference between 4½ per cent and the prevailing interest rate represents the annual cost to the company of keeping a steady workman on the job and keeping down labor turnover and may save it several times that sum.

As labor turnover is supposed to cost from \$40 for unskilled men up to as much as \$250 for skilled workmen, it would seem, from this point of view, a real economy, as the loss of interest would amount to only \$60 per annum.

The importance of making proper provision in any sales plan for the amortization of both first and second mortgages should be emphasized. We recognize the fact that a house will not and does not last forever, yet this fact seems to be lost sight of in the usual negotiation for mortgages. The financial difficulties of many mortgagees may be traced to the fact that mortgages placed on a conservative basis soon become very poorly secured if the mortgage debt is not reduced. Whenever a man buys an automobile he has to reduce his debt very quickly; in buying pianos or furniture on the installment basis, his repayments on principal are usually as large or larger than the amount of interest he is paying on his debt. The same idea ought to be adopted in the purchase of a house, as even the best-built house has plumbing, roofing, hardware and many other items that are wearing out. Most men will readily see the advantages of amortization. The continually reducing charges for interest and the progressive increase in repayments of principal are very attractive. With money at 6 or 6½ per cent a mortgage can be reduced very quickly on a moderate amortization payment.

Coöperative Housing

Much interest is being shown in copartnership or coöperative housing, which is being tried in several New York City apartment houses and is the plan adopted by the English garden city companies. Under this system a company is organized to purchase and develop real estate and the stockholders are admitted as tenants to the property. The usual scheme is for each man to purchase stock to the value of half the cost of his house and land, the other half being carried by a mortgage on the whole property. His rent is sufficient to amortize the mortgage in 7 to 12 years, and then the housing company can either reduce rents or pay large dividends.

To apply this system to the housing of the working classes

would necessitate the placing of blocks of stock in the hands of employers and charging enough rent to pay for the purchase of the stock by tenants from the block holders in monthly or annual installments instead of selling the whole of the stock to the tenants at the start. The rent paid would be large enough to take care of installment payments on the stock, as well as the amortization of the bonds. A rental of 12 per cent of the cost of the development would amortize the bonds and place the whole of the stock in the hands of the tenant in about 27 years.

The tenant in signing a rent agreement will acquire the right to receive annually second preferred stock to the amount of one-sixth of the rental paid, this stock being turned over to him in quarterly installments of two shares each. In addition to this he will be given one share of common stock (which carries with it voting privileges) as soon as his holdings in preferred stock reach $100, and one additional share for each additional $100 he acquires.

At the end of twenty-five years the whole of the second preferred stock will be in the hands of the tenants and half of the common stock will be held by them, the treasury stock being exhausted for this purpose.

In the twenty-seventh year the bonds will be entirely redeemed, and if the rent remains at the same figure there would thereafter remain $69,000 per annum available for dividends on the common stock. Probably $5 per share would be used for this purpose and the remainder carried to surplus, so that each tenant would receive $370 in dividends, viz., $245 on his preferred stock and $125 on his common stock.

The original guarantors of the preferred stock who have been holding common stock for all this time, without receiving a dividend, would receive a compensation for the risk taken in lending their credit, in the shape of $25,000 per annum dividend.

This plan has a saving incentive that would appeal to a great many workmen. Some arrangement could be made by which they could transfer from smaller to larger houses as their families increased in size.

It will be desirable to guarantee to the tenant a market for his preferred stock in case he wishes to vacate the house and leave the town, so as to remove from his mind the fear of loss which is otherwise likely to deter him from entering the scheme. It is not probable that it will be necessary to maintain this guarantee very long, as in a few years the value of the assets behind it, as the bonds are retired, will make it worth more than the purchase price.

The advantage of such a plan to the employer is that all he has to do is to guarantee an annual dividend of small amount and his funds are not otherwise tied up.

The advantage to the tenant is that he has the freedom of a tenant and yet shares the profits of the landlord and he acquires by installments a liquid investment in a housing property. He has all the rights of a householder except the speculative selling privilege and he is relieved of the fear of loss through depreciation or forced sale.

In higher-class developments where purchasers are better provided with funds, the preferred stock can be sold outright to them at the commencement, and the rental can be reduced by 2 per cent.

The plan has so many obvious merits that it is certainly worth trying out on a large scale, although it is feared that the constitutional dislike of the American workmen to any form of coöperative merchandising may prove a bar to its success. It may be that one or two successful demonstrations, however, will show that the successful solution of America's housing problems lies in this direction.

Our housing problems can be solved only by action. We should strive to put the business of housing on a self-supporting basis, for we have not solved the problem if our housing does not pay its way. We may make some mistakes in the steps we take, but if all those who are trying to remedy the present state of affairs will work together, we can overcome all the difficulties and solve our problems to the lasting benefit of our country and our homes.

LIQUID FUEL

In the last few months evidence has been accumulating to show the serious situation with respect to liquid fuels, in this country and abroad.

In England, the government has already realized the urgency of the situation and its importance for the future and has decided to render assistance to the industry through the purchase of bonds of one of the largest oil companies, the so-called Shell Group, by which means it will be supplied with working capital.

In America the question has been left largely to private initiative, with the only exception that a new Oil Land Leasing Bill may open new fields for increasing the production of oils.

The consumption of mineral-oil fuels in motor cars and in marine and stationary engines has grown so tremendously in the last five years that unless new sources of fabulous wealth are discovered the end of our liquid-fuel supplies is clearly in sight. In a recent statement the Director of the U. S. Geological Survey, George Otis Smith, estimated that the present known supplies will last only in the neighborhood of twenty years.

It is of interest, therefore, to review briefly what has been done recently to supplement mineral oils or to increase their usefulness. The work has been carried on in several directions, of which the following may be mentioned without, however, indicating the relative importance of the various remedies by the order in which they are enumerated.

During the war the Submarine Defense Association developed the so-called colloidal fuel, a mixture of oil and pulverized coal where the coal is held in suspension in the oil through the presence of a material called by its inventors the "fixateur." It is claimed that this material may be used for oil-fired furnaces in about the same manner as oil alone, and that for a given weight of oil it has a very much higher heat capacity, than oil alone, due to the presence of suspended coal.

Next, in particular reference to motor cars, may be mentioned the possible use of engines of the Diesel type, reference to which is made in an article in the Engineering Survey of this number. Numerous attempts have been made in this direction without conspicuous success, which the author of the article referred to explains by claiming that Diesel-engine manufacturers are too busy to attempt the problem, while motor-car manufacturers do not know enough about Diesel engines. The use of Diesel engines on motor cars would relieve the situation to the extent of permitting the use of unrefined oils, instead of only such upper fractions of distillation as gasoline and kerosene.

Mention should be made, also, of various products of coal distilation such as benzol, products of its hydrogenation, and motor spirits. The production of these depends on the availability in this country of coals with high nitrogen content and such coals do not appear to be very numerous.

The last, and possibly the most promising solution of the liquid-fuel problem, in particular for motor vehicles, appears to be the use of alcohol, and it is interesting to note in this connection (1) that fuels with alcohol base have recently been used with great success in motor vehicles in this country, in Europe, and especially in South Africa; and (2) that new sources for the production of alcohol are constantly being discovered. In addition to the generally known vegetable sources, of recent years methods have been developed for the production of alcohol from sawdust, from refuse of cane-sugar manufacture, from calcium carbides, and recently, at the Skinningrove Works, from coal gas. As the largest and best-known field of consumption of alcohol in this country has been destroyed for the time being, the use of alcohol for power purposes would not meet with the competition which it would formerly have had and the price of alcohol should not be high, especially as compared with the prices of gasoline now prevailing and expected in the near future. There are certain difficulties in the way of wide use of alcohol as a fuel, which, however, are of a non-technical nature and will not be discussed here. It may be stated, however, that the discovery of a cheap, positive and reliable denaturant would go a long way toward making possible the wide adoption of alcohol for power purposes.

ENGINEERING RESEARCH

A Department Conducted by the Research Committee of the A. S. M. E.

A—Research Results

The purpose of this section of Engineering Research is to give the origin of research information which has been completed, to give a résumé of research results with formulæ or curves where such may be readily given, and to report results of non-extensive researches which in the opinion of the investigators do not warrant a paper.

Apparatus and Instruments A9-20 Air Analyzer for Cements. Technologic Paper No. 48 of the Bureau of Standards describes an air analyzer for determining the fineness of cements and describes measurements to determine the size of the particles passing through a 100- or 200-mesh sieve as compared with maximum-size particles blown off by Nos. 1, 2 and 3 nozzles of air analyzers. In reporting the results of tests it has been at all times desirable to know the maximum-size particle passing through a 300-mesh sieve. The following table gives the mean results of two dimensional measurements:

100 mesh = 0.00793 in.	No. 1 nozzle = 0.00216 in.
200 mesh = 0.00428 in.	No. 2 nozzle = 0.00154 in.
300 mesh = 0.00301 in.	No. 3 nozzle = 0.00076 in.

Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Cement and Other Building Materials A2-20 Finely Ground Cement. The Bureau of Standards has completed a series of comparative tests on cement of normal fineness in which 86 per cent passes through a 200-mesh sieve and on finely ground cement in which 98 per cent passes through a 200-mesh sieve. The two cements were tested neat, in 1 : 3 sand mortar and in concretes of 1 : 1½ : 2, 1 : 2 : 4 and 1 : 3 : 6. The following results were obtained:

1 The strengths of the concrete from the fine cement were regularly and consistently greater than those made with the normal cement so far as the tests have been completed.

2 The percentage increase in the strength of the fine cement concrete varied as follows:

	2 days	7 days	28 days	3 mo.	6 mo.
Minimum gain	90	50	30	21	14
Average gain	121	66	56	41	42

3 The strength increases in lb. per sq. in. were greater in the mixes containing the greater proportion of cement.

4 The approximate savings for the same strength at 28 days if consistencies and aggregates were the same were found to amount to 1.2 to 2.1 bags of cement per cu. yd.

5 When used in 1 : 3 mortar the fine cements produced a more marked percentage increase than when used in concrete, but the percentage increases in neat mixtures were of the same order as those in the concretes.

6 The fine cement requires no more water than normal cement.

7 The lumps of very fine material were not broken up under the sieving action, but when tested by the air analyzer these were broken up and the results gave a true indication of the fineness. Hence it is recommended that air analyzers be used in determining the fineness of very fine cements.

Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Cement and Other Building Materials A3-20 Adherence of Gypsum to Concrete. The Bureau of Standards has made the following determinations from a research on the adherence of gypsum to concrete:

1 There seems to be no detrimental reaction between the two materials; the tensile strength of the mixture of gypsum and cement is very nearly equal to their combined strengths, dependent upon the proportions of the two ingredients used.

2 The suction of the surface to which the plaster is applied is an extremely important factor; for example, if gypsum plaster is applied to a dry concrete surface, the suction of the concrete will take so much water out of the gypsum that it will prevent its proper hardening.

3 The expansion of neat cement, when wet, is of an entirely different order from the expansion of neat gypsum, and a bond between the two materials can be permanently maintained only when enough sand is added to both materials to reduce the expansion for both.

The above-mentioned research work has been supported by the Gypsum Industries Association and a report covering it has recently been made to them. Address Bureau of Standards, Washington, D. C. S. W. Stratton, Director.

Electric Power A1-20 Corona Discharge. Bulletin No. 114 of the Engineering Experiment Station of the University of Illinois on Corona Discharge by E. H. Warner and J. H. Kunz has been issued. The Bulletin is divided into eleven chapters and contains a bibliography of 2½ pages. The titles of the chapters are as follows:

I Introduction (with statement of phenomenon and description of apparatus

II General Appearance of Corona about a Wire in a Cylinder (The appearance of the corona with direct current and wire positive in air; negative in air; positive in hydrogen and negative in hydrogen with direct current is shown as well as the appearance of the corona with alternating current)

III The Starting Point of the Corona

IV Characteristic Curves

V Additional Factors Affecting the Starting Point and the Corona Current

VI Alternating-Current Rectification

VII Distribution of the Potential in the Corona Tube

VIII The Pressure Increase in the Corona

IX Ozone Formation in the Corona

X The Influence of a Series Spark on the Corona

XI Other Types of Corona Discharge.

Engineering Experiment Station, University of Illinois, Urbana, Ill. Address Dean C. R. Richards, Director.

Electric Power A2-20 Power Factor. A mathematical study of the theoretical side of the effect of power factor on economy for the purpose of defining power factor in a quantitative way has been made by the Bureau of Standards and will be presented at the June Convention of the American Institute of Electrical Engineers. The purpose of this study was to aid the Joint Committee of the Institute and the National Electric Light Association in the study of this question. The paper points out the type of definition which most logically fits a number of different cases and shows the essentially conflicting character of some of the requirements which a single definition should satisfy. It is suggested that an additional quantity called the balance factor will enable these requirements to be made in a more satisfactory manner. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Fuels, Gas, Tar and Coke A4-20 Natural Gas. The University of Kansas Experiment Station has issued Engineering Bulletin No. 11, by H. C. Allen and E. E. Lyder, on a chemical survey of the natural gases of Kansas and Oklahoma. The Bulletin contains 101 pages and discusses the gas and oil development in the two states, the theory of accumulation, the properties of natural gas, the methods of determining constituents of natural gas and its heating values, and gives a survey of the fields and analysis of typical gases. The variations in composition and pressure, earlier tests, analyses of other gases of North America and foreign countries and comparative costs between natural gas and coal are also discussed.

The Bulletin describes the modification of apparatus for analysis of gases and shows a great variation in the percentage of hydrocarbons and nitrogen present. The maximum percentage of CO_2 was found to be slightly over 4 per cent. The report shows that the shallower gases are poorer in quality than the deeper ones from the same locality. Analytical data show the effect of mixing poorer gas with good gas. The principal causes of complaint from the domestic consumer are low pressure, poor quality and variation in quality. No air is intentionally mixed with the gas by the companies. The report shows possibilities for the recovery of gasoline by absorption processes and of utilizing geological means in oil and development work.

Address W. A. Whitaker, Director of the Division of State Chemical Research, University of Kansas, Manhattan, Kan.

Fuel Utilization A1-20 Fuel Research. The report of the Fuel Research Board of the Department of Scientific and Industrial Research of Great Britain for the years 1918-1919 is now on sale. It deals with the following subjects: The immediate importance of fuel economy; oil fuel for the navy and the mercantile marine; the fuel-research station and functions; survey of the national coal resources from the physical and chemical points of view; work at the fuel-research station; domestic heating; air pollution; pulverized coal; peat inquiries; use of alcohol as fuel; gas standards.

The report contains appendixes on Fuel Economy and Low Temperature Carbonization, and Summary of Reports on the Efficiency of Cooking Ranges. The price is 1s. 8½d. by post and copies may be obtained from H. M. Stationery Office, Imperial House, Kingsway, London, W.C.

Fuels, Gas, Tar and Coke A5-20 The United Gas Improvement Contracting Company has developed a device by which a water-gas set may be operated with promptness and celerity by a proper adjustment and arrangement of valves. This automatic control is placed in a small dustproof case of cast iron mounted on cast-iron legs and occupying 6 sq. ft. of floor space. It is operated by 1/10-hp. electric motor. It is interlocking and foolproof and permits one man to control several sets of apparatus and the gas maker may handle his own fuel and do other work. It permits shorter cycles. United Gas Improvement Contracting Company, Philadelphia, Pa. Address J. M. Rusby, Engineer of Tests.

Metallurgy and Metallography A6-20 Melting Point of Slags. The Bureau of Standards is preparing for publication a paper on a recent investigation of the melting point of various slags typical of those which occur in different lines of metallurgy. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Metallurgy and Metallography A7-20 Mechanical Working of Metals. The Bureau of Standards has shown that it is possible to melt nickel in an atmosphere of hydrogen so as to prevent the formation of slight traces of oxide which causes crumbling in the working of the metal. The hydrogen also acts as a dioxidizer. Wires as small as 0.05 mm. diameter have been drawn from some of the pure nickel thus melted. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Metallurgy and Metallography A8-20 Behavior of Hardened Steel upon Heating. The Bureau of Standards has recently investigated the effect of time in tempering hardened steels at relatively low temperatures. It has been found that the transformation which is suppressed by rapid cooling of the metal in hardening occurs upon reheating to 200 or 250 deg. cent. By heating for a long time at a lower temperature results similar to that obtained in a shorter time by higher temperature is produced. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Metallurgy and Metallography A9-20 Aluminum-Alloy Castings. Blowholes, Porosity and Unsoundness in Aluminum-Alloy Castings. Technical Paper 241 of the Bureau of Mines, by Robert J. Anderson, 31 pages.

The Bulletin has the following sectional headings: Unsoundness in general and factors affecting it; definitions of blowholes, porosity and unsoundness; general factors affecting soundness of castings; gases in aluminum; solidification of metals; analogy with steel; effect of casting temperature; effect of method of melting; effect of rate of melting; effect of method of molding; effect of design of castings; effect of quality of ingot; so-called deoxidation of aluminum; description of experiments; metallography of unsoundness; radiography of castings; miscellaneous consideration; conclusions and publications on metallurgy.

The general conclusions show that broad generalizations cannot be drawn from the results of the experimental work, the experience of foundries and the contradictory literature. However, it is possible to recognize the existence of a large number of variables that may conduce to unsoundness and blowholes. The number of blowholes present is a function of the pouring temperature; the higher the pouring temperature, the greater the amount of blowholes and the more unsound the casting. Unsoundness varies with the temperature to which the charge is heated. The higher the temperature the more unsound the casting, irrespective of the pouring temperature.

Unsoundness is a function of the length of time of melting. The longer the melting is held the more unsound the castings. Melting and pouring should be carefully supervised. Close pyrometric control is necessary. It is better to have the molding floor wait for the metal rather than for the metal to wait for the floor.

Address Bureau of Mines, Washington, D. C. Van H. Manning, Director.

Metallurgy and Metallography A10-20 Magnetic Uniformity of Steel. See *Properties of Engineering Materials, A9-20*

Properties of Engineering Materials A7-20 Bakelite. Modulus of Rupture. Computed by formula $S = 3PL/2BD^2$. Determined from ½ by ½ by 5-in. specimens. With span of 2 in., $S = 12{,}500$ lb. per sq. in., with span of 3 in., $S = 12{,}460$ lb., and with span of 4 in., $S = 13{,}170$ lb.

Moduli of Elasticity. Determined in above specimen by formula $E = WL^3/4ABD^3$: for 2-in. span $E = 760{,}000$ lb. per sq. in., for 3-in. span, 887,000 lb.; for 4-in. span, 944,000 lb.

These tests were repeated, giving about the same stress as before, but slightly higher moduli of elasticity for 3-in. and 4-in. span.

Address General Bakelite Company, Gilbert L. Peaks, Electrical Engineer, Perth Amboy, N. J.

B—Research in Progress

The purpose of this section of Engineering Research is to bring together those who are working on the same problem for coöperation, to prevent unnecessary duplication of work and to inform the profession of the investigators who are engaged upon research problems. The addresses of these investigators are given for the purpose of correspondence.

Apparatus and Instruments B4-20 Wave Meter The development of a design of heterodyne wave meter for undamped wave work by Prof. R. W. Goddard, New Mexico College of Agriculture and Mechanic Arts, State College, New Mexico. Address A. F. Barnes, Dean of Engineering.

Electrical Communication B2-20 Wave Meter. See *Apparatus and Instruments, B4-20.*

Electrical Communication B3-20 Spark Frequency and Power. An investigation of the relation of spark frequency on power input to damped wave systems of wireless with given wave lengths and capacity condensers. Prof. R. W. Goddard, New Mexico College of Agriculture and Mechanic Arts, State College, New Mexico. Address Dean A. F. Barnes.

Electric Power B2-20 Heat by Induction and Eddy Currents. An investigation on heat by conduction and eddy currents in high frequency currents by Prof. R. W. Goddard, New Mexico College of Agriculture and Mechanic Arts, State College, New Mexico. Address Dean A. F. Barnes.

Fuels, Gas, Tar and Coke F11-20 Volatility of Motor Fuels. An investigation to determine by vapor-tension apparatus the minimum temperature to establish a stable mixture of air and gasoline vapor in combining proportions. Address Frank A. Howard, Standard Oil Company, 26 Broadway, N. Y.

Fuels, Gas, Tar and Coke F12-20 Crushed Fuel. A new method of burning crushed fuel is being developed at Purdue University. Fuel is introduced after crushing to small-size grains through tuyeres at one side of a circular hearth. The coal is introduced by means of an air current through a fan blower, additional air for combustion being introduced by side openings. High capacity has been obtained with ease of control and regulation. The cost of operation is much less than that of the pulverized coal methods. Address Prof. G. A. Young, Purdue University, Lafayette, Ind.

Internal-Combustion Motors B5-20 Mixture Requirements. The mixture requirements of internal-combustion engines. Investigation by O. C. Berry, Engineering Experiment Station, Lafayette, Ind. Address C. H. Benjamin, Director.

Metallurgy and Metallography B6-20 Refractory Crucibles. The Bureau of Standards is working on the method of making crucibles from highly refractory oxides and minerals. Titanium oxide, zirconium dioxide and carborundum firesand have been used. Bureau of Standards, Washington, D. C. S. W. Stratton, Director.

Petroleum, Asphalt and Wood Products B3-20 Volatility of Motor Fuels. See *Fuels, Gas, Tar and Coke, F11-20.*

Pumps B2-20 Electrically Driven Pumps in Small Water Works. Investigation by G. C. Blalock and D. D. Ewing at the Engineering Experiment Station, Purdue University, Lafayette, Ind. Address C. H. Benjamin, Director.

Wood Products B1-20 Preservation. Preservative Treatment of Wood Poles. An investigation by R. V. Achatz, Purdue University, Lafayette, Ind. Address C. H. Benjamin, Director.

E—Personal Notes

The purpose of this section of Engineering Research is to give notes of a personal nature regarding the personnel of various laboratories, methods of procedure for commercial work or notes regarding the conduct of various laboratories.

Purdue University E2-20 The Engineering Experiment Station of Purdue University has just issued a Bulletin describing their work, the equipment and the experiments in progress. A copy of this may be obtained by addressing Dean C. H. Benjamin, Director, Purdue University, Lafayette, Ind.

The Engineering Experiment Station is planning to include the following subjects for study during the coming year:

A Friction and Endurance of Lubricating Oils
B The Slippage and Windage of High-Speed Belts and Pulleys
C Composition of so-called Standard Liquid Fuels
D Combustion of Crushed and Pulverized Coal
E Effect of Load and Power Factor on Central-Station Rates
F Farm Lighting Plants
G Adaptation of Circular Energy for Service in the House and on the Farm
H Electrification of Grain Elevators.

The Station is prepared to do commercial testing at the established rates.

The plans for industrial coöperation are similar to those employed by other laboratories. Industrial fellowships may be founded by individuals or corporations, the university supplying the necessary facilities for the work. The Station is established primarily to afford opportunities for scientific research which would be of direct benefit to the people of the state and the nation.

ENGINEERING SURVEY

A Review of Progress and Attainment in Mechanical Engineering and Related Fields, as Gathered from Current Technical Periodicals and Other Sources

SUBJECTS OF THIS MONTH'S ABSTRACTS

AERONAUTICS

Graphical and Mathematical Investigation of Aeroplane Ranges and Useful Loads

A Study of Aeroplane Ranges and Useful Loads, J. G. Coffin. The report is in three parts, the first dealing with numerical and graphical analyses of the conditions for maximum range, fuel consumption, determination of the maximum load for a given objective and consequences of flying at maximum speed, together with conditions for flying at minimum power. Graphical methods are chiefly used.

In the second part practically the same factors as were considered in the first part are investigated again, but this time by mathematical methods. Equations are deduced such as time-weight, time-distance, weight-distance and useful-load-objective distance. Proof is presented to the effect that the load-objective curve is a straight line. The third part considers the effect of wind on range.

The report is of particular interest when taken in connection with the paper on Rectilinear Flight of Aeroplanes, by A. Rateau, Hon. Mem. Am. Soc. M. E., published in the May, 1920, issue of Mechanical Engineering, with this distinction, however, that while Professor Rateau makes the attainment of the maximum cruising radius of an aeroplane dependent on the altitude of flight, this latter element is introduced into calculations by the author only incidentally. Doctor Coffin, however, also attaches importance to flight at high levels and cites its advantages in the following manner:

a The motor running full open will probably use less fuel per horsepower than has been assumed for throttle, say, in the ratio of 0.6 to 0.7.

b The motor running at a higher speed can develop slightly more power with proper adjustment, which will increase the height, and therefore the speed.

c A very good third reason is that the duration of the flight will be considerably lessened and this together with

d The increased safety due to high altitude and greater flying speed lead to the conclusion that: For bombing purposes the aviator should fly at a certain predetermined constant angle of attack; he should allow the plane to rise as the load diminishes.

Since the work consumed in rising to the higher level is at least partially returned when the machine glides down at the end of the trip without power, these works have not been considered.

The following results have been attained mathematically as regards flight in calm air:

1 The machine should fly at a constant angle of attack, the angle corresponding to the minimum value of W/R, where W is the weight and R the total resistance.

2 It is practically immaterial whether the machine flies high or low as far as range is concerned.

3 There is an advantage in flying high in that the time is much reduced.

4 The resistance is proportional to the weight at a given altitude.

5 The result of flying at maximum speed is a very much diminished range, or for a given range a very much diminished useful load.

6 The result of flying at minimum power is to slightly reduce the range.

7 The times of flight at the same level for flying at best range speed and at minimum power speed are practically the same.

8 The condition for best range is shown.

9 The weight-time curve is deduced.

10 The range-time curve is deduced.

11 The weight-range curve is deduced.

12 The effect of altitude has been taken into account.

13 The time is greatly diminished for flying at corresponding levels.

14 The theory checks closely with the ordinary methods of Part I.

Part 3 gives a theoretical solution of the effect of wind on range. First, a proof of a method for determining the L/D and air speed for the machine under any wind conditions is given. A new method is shown wherein but one P-V curve is required for any load and any wind speed.

Variations in L/D for changes in load and wind speed are derived and checked against the usual methods, and the weight-distance formula is derived as modified by winds.

The results of interest for flight in winds are:

1 The angle of attack changes but slightly when flying against winds of reasonable strength, and but very slightly when flying with winds of any strength.

2 The altitude of flight affects the range. The reason being that higher speeds are attained at higher altitudes and the ratio of air speed to wind speed changes. However, as wind speeds change with altitude it does not seem worth while to go into the matter more fully.

3 Other things being equal, it is slightly advantageous to fly high, especially as to time of flight. (*National Advisory Committee for Aeronautics*, Report No. 69. Preprint from 5th Annual Report, Washington, D. C., 1920, pp. 6-29, 11 figs., *t*)

BUREAU OF STANDARDS (See also Refractories)

Notes on the Critical Ranges of Some Commercial Nickel Steels, H. Scott. The transformations in some commercial nickel steels have been studied by means of thermal analysis. The Ac_1 transformation, the temperature of which is of direct practical

value in heat-treatment specifications, is also the most difficult to definitely locate. It is found that slow rates of heating give better definition of this point and that the end of the Ac_3 range, as interpreted from the thermal curves, corresponds to the minimum temperature at which all the ferrite is in solution. The effect of rate of temperature change and of nickel content on the critical ranges of the steels, which approximate 0.40 per cent carbon content, is shown in curves, and the effect of nickel and carbon on the end of Ac_3 is deduced from the data obtained and those of other observers whose work is discussed. The effect of nickel on the A_1 transformation is to lower Ac_1 by 10.5 deg. cent. and Ar_1 by 21.5 deg. cent. for each 1 per cent nickel over the range 0 to 4 per cent nickel. The eutectoid ratio is also decreased by 0.042 per cent carbon for each 1 per cent nickel added over the same range. (Abstract of *Scientific Paper of the Bureau of Standards*, No. 376, *e*)

THE INTERCRYSTALLINE BRITTLENESS OF LEAD, Henry S. Rawdon. Sheet lead sometimes assumes a very brittle granular form during service, due to corrosion. An explanation which has been offered by previous investigators for this change in properties is that it is due to an allotropic transformation, the product resulting from the change being analogous to the well-known "gray tin." Contact with an electrolyte, particularly a weak acid solution of a lead salt, has been claimed to be the agency by which the transformation is brought about.

Metallographic examination of the granular "allotropic" lead shows that each grain has the characteristic properties of the ordinary form of lead. The intercrystalline cohesion of the grains for one another, however, has been so weakened that the material has a granular appearance.

The rate at which the intercrystalline brittleness is brought about is proportional to the amount of impurities and to the concentration of acid in the solution in which the lead is placed. Practically all the impurities which are found in lead are lodged in between the grains. The preferential attack by the corroding agent for these impurities, and perhaps also for the "amorphous intercrystalline cement," accounts for the brittleness produced. Investigation showed that specimens of exceptionally pure lead (99.993 per cent), when immersed for 24 days in a neutral solution of lead acetate, became appreciably embrittled by the formation of minute intercrystalline fissures. No evidence of the existence of an allotropic form of lead similar to gray tin could be obtained. (*Scientific Paper of the Bureau of Standards*, No. 377, *e*)

CHEMICAL ENGINEERING

ALCOHOL AS A BY-PRODUCT OF THE DISTILLATION OF COAL, E. de Loisy. On December 15, 1919, H. Le Chatelier presented to the Academy of Sciences, in Paris, a short paper written by the present author describing the process of synthetic production of alcohol as a by-product of coal distillation. By a queer coincidence on the same day E. Bury and O. Ollander presented a paper on the same subject to the Cleveland Institution of Engineers, describing the same process as developed at the Skinningrove Works.

Briefly, the process is based on the following facts: It has been known for a long time that illuminating gas contains about 2 per cent of ethylene, and it has been known that ethylene can be converted into alcohol. The question was, however, (1) how to separate the ethylene from the gas, and (2) the best method for its conversion into alcohol.

As regards the former problem, it was solved during the war when vast quantities of ethylene became necessary for the manufacture of so-called mustard gas in connection with the Chemical Warfare Service. A process was developed for segregating ethylene in coke-oven gas by absorbing it in charcoal, the gas having been previously washed in lime water to free it from hydrogen sulphide and carbon dioxide. In fact, during the war a continuous process was developed such that at one stage cold charcoal absorbed the gas and liberated it at another stage at a temperature of about 350 deg. cent., whereupon it was ready to be cooled and used over again.

The next stages in the conversion into alcohol comprise the absorption of ethylene by concentrated sulphuric acid, which led to its transformation into acid ethyl sulphate or sulphovinic acid, and the treatment of the latter which could be carried out in two ways—either by oxidation of the acid by ozonized air or electrolysis with the view of obtaining acetic acid, or by hydrolysis, in which case alcohol is obtained.

The process is of interest in view of the apparently growing demand for power alcohol. (*Revue de Métallurgie*, vol. 17, no. 2, Feb. 1920, pp. 56-62, *ep*)

FOUNDRY

DIRECT BLAST-FURNACE CASTINGS, F. L. Prentiss. An article (Making Ore Pile Part of Automobile Plant) describing the blast-furnace installation at the Ford Motor Company intended to produce the iron needed in the manufacture of Ford cars.

One of the main interesting features of this plant is the attempt, only partly realized, to pour hot metal directly from the furnace to the molds in the foundry eliminating remelting the pig iron in the foundry cupolas. Mr. Ford, believing that this could be accomplished, some time ago set his engineering and foundry departments to work on the problems involved. In the process as it has been worked out the cupolas will not be eliminated entirely, but the metal from the blast furnace and the metal from the cupolas will be mixed in definite proportions. It is stated that tests have proved that high-grade castings possessing all the qualities required for machining will be produced by this process. (*The Iron Age*, vol. 105, no. 19, May 6, 1920, pp. 1295-1302 and one sheet of illustrations, 11 figs., *dA*)

FUELS AND FIRING (See also Chemical Engineering; Power Plants)

Decomposition Point in Sub-Bituminous Coal—University of Washington Investigation

LOW-TEMPERATURE DISTILLATION OF SUB-BITUMINOUS COAL, H. K. Benson and R. E. Canfield. Data of an investigation carried out at the Laboratory of Industrial Chemistry, University of Washington, Seattle, Wash., the investigation being on a semi-commercial scale.

The sample of coal was black in color with a brown-black streak. It had a rather dull luster, was massive in texture, without joints, and had a conchoidal fracture. The approximate analysis showed in air-dry samples a sulphur content of 0.36, volatiles 39.4, and nitrogen 1.47 per cent.

The most striking result of the investigation is the well-defined decomposition point between 350 and 400 deg. cent. This marks a maximum in the yield of tar oils, and an abrupt rise in the quantities of nitrogen and methane. A decrease in paraffins also occurs at this point, suggesting the possibility of the cracking of the oils.

Rather interesting data have been secured on the yield of ammonium sulphate in pounds per ton of coal (Fig. 1).

Attention is called to the following general conclusions:

About 3.5 per cent of the coal may be obtained as raw oils.

These raw oils are a mixture of coal tar and petroleum-like oil, with the former predominating.

The yield of light oils decreases rapidly as the temperature increases, that of the paraffin oils less rapidly, while the yield of the medium oils remains fairly constant.

About 5.3 lb. of paraffin wax per ton of coal may be obtained at 350 deg. cent.

The gas given off up to 600 deg. cent. is small in volume and low in heat value, but relatively high in illuminants.

The residue at 350 deg. has a calorific value of 12,700 B.t.u., which is an increase of 22.8 per cent over the coal as mined, and of 14.7 per cent over the dry coal. (*The Journal of Industrial and Engineering Chemistry*, vol. 12, no. 5, May 1920, pp. 443-446, 4 figs., *e*)

FURNACES

HEAT-TREATING GAS FURNACES, H. M. Thornton. In the course of a paper on Gas in Relation to Increased Output and National Economy, the author presents some interesting data on the use of gas for heat treatment and describes some of the furnaces used in England.

Among these are the so-called L. P. G. A. (low-pressure gas and air) used for annealing high-speed steel in Sheffield. This furnace is of the "over-fired" type, which means that the gas supply at normal city pressure is led through ports at one or both sides, where it comes into contact with the air (supplied at approximately 2 in. water gage) obtained from a small fan. This air is well preheated by being taken through the opposite side of the furnace in fireclay tubes and then passed along the bottom of the furnace in close proximity of the hot waste products.

Combustion takes place inside the working chamber round the furnace walls, the usual combustion chamber being absent. The flames produced keep up well and sweep round the arch. The products of combustion then pass to the opposite side of the furnace, are carried under the floor and up the other side away to the flue. All the waste heat possible is utilized in preheating the air, thus promoting economy and efficiency.

With pressure inside the furnace, air cannot enter through the door or any other orifices even when they are opened for any purpose.

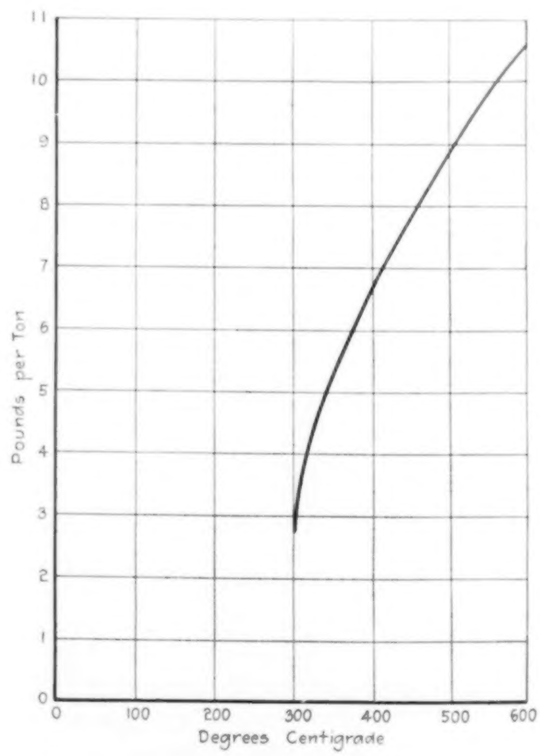

FIG. 1 YIELD OF AMMONIA IN LOW-TEMPERATURE DISTILLATION OF SUB-BITUMINOUS COAL

Another of the furnaces mentioned is the Rotoflam tool-hardening furnace, Fig. 2. In this furnace the chamber is circular and is heated by gas and air-blast burners, two of which are used—one at the top and one at the bottom of the chamber, and equidistant on the circumference. The flame from the burners encircles the inside walls of the furnace and maintains a temperature suitable for any class of high-speed steel.

There is no direct flame contact, all the heating being done by radiation. Therefore there is no excessive heat at any one point, and a gradual soaking heat is insured. There is no flue or chimney in this furnace, the exhaust gases being expelled automatically through the mouth. This arrangement makes it impossible for any free air from outside to enter the chamber and oxidize the steel.

The next furnace described is the Brayshaw, also used for heat-treating. In this the upper chamber is heated by waste heat from the lower and serves for preheating tools, etc., before they are put into the lower furnace, raising them gradually to a medium temperature preparatory to the final quick heating required to bring them up to the high temperature necessary for hardening.

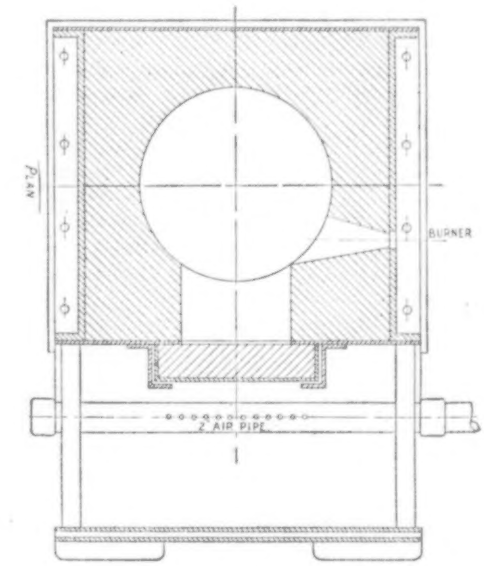

FIG. 2 ROTOFLAM TOOL HARDENING FURNACE (SECTIONAL VIEW)

The main advantage claimed in the paper for gas-heated heat-treating furnaces is that they permit such a close control of conditions as to reduce the waste due to improper heat treatment to very low figures.

Several other furnaces are described and comparative data given on the cost of coal and gas firing for certain purposes. (*Journal of the Royal Society of Arts*, vol. 68, no. 3517, Apr. 16, 1920, pp. 346-366, 17 figs., *dp*)

GAS ENGINEERING (See Furnaces)

HEAT TREATMENT (See Furnaces)

HOISTING MACHINERY

Principles of Design of Shipyard Cranes and Description of Hok Crane

SHIPYARD CRANE, W. H. Hok. Description of a crane used in a Swedish yard (Lindholmen Shipbuilding and Engineering Company of Gothenburg).

A large number of European yards adhere to the ordinary mast-and-derrick shipyard crane. Invariably the hoisting winch, whether steam or electric, was placed on the ground level with the attendant trouble of having the hoisting rope leading from the winch to the derrick mast always entangled in bars, plates and all sorts of rubbish. This arrangement also necessitated having signalmen placed here and there, as the winch operator could not as a rule see what he was doing.

Other yards are equipped with expensive overhead traveling cranes, such as gantry cranes, or with cantilever cranes common to two contiguous berths and running either on rails laid on the ground or on a high gantry erected between the berths. Revolving cranes are also used, either of the high-power type traveling on rails laid on the ground or a small revolving crane running on rails laid on a gantry erected between berths.

The author of the paper investigated the crane arrangements on some two score of plants and found that, on the whole, nobody seemed satisfied with the crane arrangements he possessed, and the cranes not only were not standardized, but it was almost always the case that a different system of cranes was tried at almost

every building berth in the same yard and for every new berth laid down.

The conclusions to which the author came as regards the general principles of crane construction are, as follows:

1 The mast-and-derrick arrangement is quite satisfactory, provided it can be so arranged that all side staying of masts can be done away with.

2 The operator's platform should be placed high above the ground on, for instance, the level of the principal weather deck of the ship, so that the operator can see what he is doing, thus obviating the necessity of using signalmen.

3 The lead from the hoisting winch to the derrick mast should not be taken along the ground among staging uprights, shoring, plates and bars, and various rubbish strewn about the ship. The lead from the winch should be free from all obstructions.

4 A space or passageway is desirable between contiguous ships to enable building material to be brought down between ships and hoisted on board from the nearest point at the ship's side, and not from the ship's end only. Such an arrangement

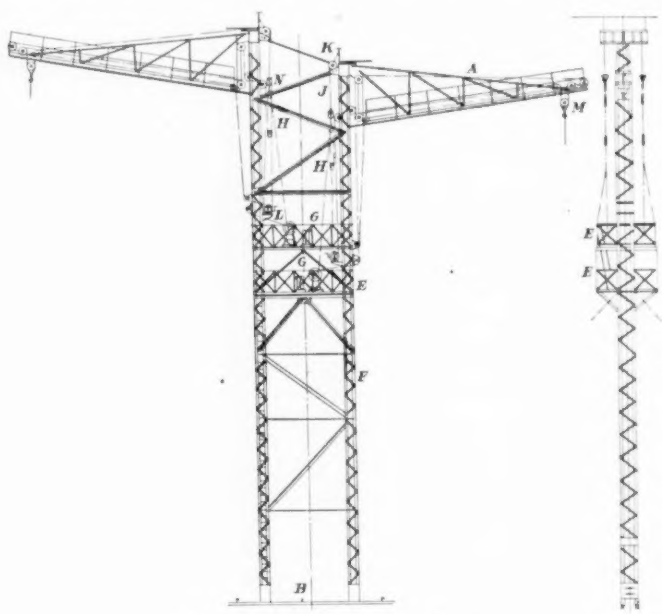

FIG. 3 HOK SHIPYARD CRANE

covers many more chances of rapid building than an arrangement based, for instance, on the material being taken in hand by the hoisting gear at the end of the ship only, because the former arrangement offers so many more points of attack on the ship than the latter.

Guided by these conclusions the author designed the stationary crane shown in Fig. 3. This type is chiefly composed of a stationary main structure and two swinging arms, the former consisting of two latticework masts placed about 15 ft. 3 in. apart from center to center, and rigidly connected to one another by cross-stays and trusses making the main structure stable in the thwartship direction, thus obviating the necessity of fitting side stays. The author calls such a structure consisting of two derrick masts rigidly connected to one another by cross-stays and trusses a *derrick frame*, in contradistinction to the solitary derrick mast. Each derrick frame carries two derricks or arms *A* which can swing about 120 deg. to each side of a vertical thwartship plane through the derrick frame, i. e., well past the center line of railway *B* laid down in the passageway between contiguous ships. The derrick frame is held in place by fore-and-aft wire stays only. For this purpose two sets of stays are fitted, the lower ones *C* partly for giving rigidity to the cranes in a fore-and-aft direction and partly for preventing collapse of a whole group of interconnected cranes in case the top and end stays *R*, or some of the top stays *D*, fitted from crane top to crane top of the group should give way.

At a suitable place above the ground two winch platforms *E* are built into the derrick frame, one above the other. Access to them is given by ladders inside the frame legs *F*.

Each crane arm and the load are controlled from the platforms *E* by a single ordinary alternating-current electric shipyard winch *G*, which means that they are controlled by one electric motor only. Hoisting and lowering are done with the winch center barrel in the ordinary way, and slewing with the extended winch ends by taking a couple of turns round the appropriate extended winch end with a loose end of a tackle *H*, actuating the wire *J*, which is carried round and fastened to the rim of the horizontal wheel *K* on top of the crane.

A spiral spring *N* is introduced above the slewing tackle for the purpose of taking up the inertia of the crane arm when it arrives at the extreme end of the swing, in this way preventing damage and unnecessary straining of the connections in case of rough usage or ignorance on the part of the man handling the crane.

The method of racking motion is described in some detail, as well as the method of erecting these cranes. (Paper read before the Institute of Engineers and Shipbuilders in Scotland, abstracted through *Marine Engineering and Canadian Merchant Service Guild Review*, vol. 10, no. 4, April 1920, pp. 84-87, 6 figs., *d*)

INTERNAL-COMBUSTION ENGINEERING (See also Thermodynamics)

Power-Recuperating Engines: Principles of Operation and Design of Valve Gear

A POWER-RECUPERATING ENGINE, Georges Funck. Discussion of the design of engines that would maintain power at altitude with supercharging. The writer discusses the operation of standard engines under various conditions on the basis of their entropy.

The power-recuperating engines are classified into two main groups, the first consisting of those having a cycle of operations such as to maintain a maximum pressure and the second a cycle to maintain a constant compression temperature, taking into account for both the atmospheric temperature variation.

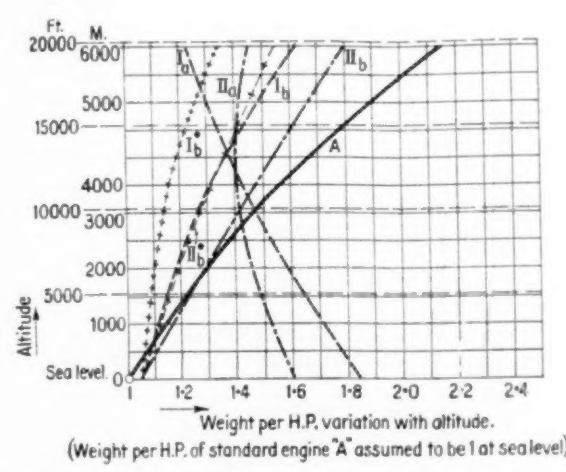

FIG. 4 CURVES OF WEIGHT PER HORSEPOWER OF ENGINES OPERATING ON VARIOUS CYCLES AS COMPARED WITH A STANDARD ENGINE AT SEA LEVEL

They may further be divided into certain subdivisions. Thus, case (*a*) represents an engine designed with a combustion space of such a size that its ratio to the total cylinder volume gives a maximum compression ratio required for the altitude at which the engine has been designed to work.

In order to vary the effective actual compression ratio as required by the altitude, it is proposed to close the inlet valve before the piston reaches the end of the stroke which amounts to having an engine with a variable compression but a constant-expansion stroke.

This cycle is really the Atkinson cycle, with the modification that the effective compression ratio is variable with the altitude while the expansion ratio is constant, until the standard cycle is attained at the predetermined altitude. In this connection Fig. 4 is of interest as showing that the weight of such an engine per unit output would be quite large at sea level.

The simplest way to perform this cycle mechanically appears to be to provide a variable inlet charge cut-off by altering the timing of the inlet valve, which could be done in several ways; for example, the valves could be operated by means of rockers mounted on eccentric pins as illustrated in Fig. 5.

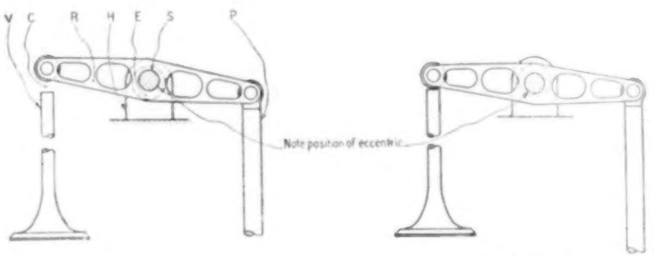

FIG. 5 VALVE OPERATION OF ATKINSON-CYCLE POWER-RECUPERATING ENGINE

By rotating on its housing H the eccentric E which carries the swivel pin S, the clearance C between the rocker R and the valve V is altered and the valve lift and duration of opening is modified, thus effecting the inlet charge cut-off.

Case (b) represents an engine so designed that the volume of combustion space is adjustable. Attempts to do this were made by introducing a second piston in the upper end of the cylinder, so located that its position can be modified at will, thereby reducing or enlarging the combustion space. This involves a complicated and inefficient valve gear. Another proposition has been made to make the whole cylinder movable up and down, which is again too complicated for immediate consideration.

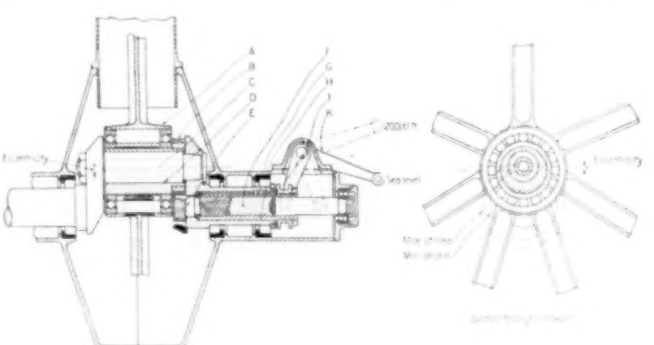

FIG. 6 RADIAL POWER-RECUPERATING ENGINE

The variable-stroke method has also been proposed. The design of a variable-stroke engine of the multi-throw type of crankshaft presents mechanical difficulties. It is, however, comparatively simple in connection with radial engines. Thus, Fig. 6 shows the design of a radial power-recuperating engine.

Over the crankpin C is fitted an eccentric sleeve D, which carries the connecting rod A mounted on ball bearings in the usual manner. The eccentric sleeve can be rotated partially round the crankpin and held in any desired position. It is obvious that by this arrangement the stroke of the piston can be altered at will. Only a small eccentricity is required to give the desired result. Even in the extreme case B of group 1, to which the curves relate, an eccentricity of 5 per cent of the shortest stroke is all that is necessary to effect power recuperation up to 20,000 ft.

In order to operate this eccentric sleeve from outside, a gear wheel B is attached to the sleeve. Into this gear meshes another wheel E carried on the spindle F, the latter being provided with a multi start quick thread as shown. A sleeve H with a corresponding internal thread engages the thread of the spindle F. This sleeve is prevented from rotating by one or more keys G located in the crankshaft in such a manner that an axial sliding motion can be imparted to the sleeve H by means of the lever I. It will be seen that by operating the outside lever K, which is coupled direct with lever I, the eccentric sleeve D can be rotated to any desired position, and maintained there while the crank is revolving, modifying the effective throw of the crank and thereby the piston stroke.

As the eccentricity is very small, the reaction of the connecting rods while under load on the eccentric sleeve is small, and no undue force would be required to operate the mechanism while the engine is running. Should there be any difficulty, however, the throttle may be closed for the short period of the change, which would be effected in steps according to the altitude. However, in proportioning the lead of the multi thread and the levers correctly, this process of operation would hardly be necessary. For the same reason the different positions of the eccentric affect the timing of the engine only to a small degree, and it should be possible to design a cam so that a satisfactory timing for all altitudes is arrived at; or such a timing may be evolved which gives the best result at the altitude at which the engine is called upon to run normally.

The article is illustrated by numerous pressure-volume diagrams worked out for the various cycles at three different levels; namely, sea level, 10,000 feet altitude, and 20,000 altitude. (*The Automobile Engineer*, vol. 10, no. 137, April 1920, pp. 145-153, *pA*)

Details of Diesel-Engine Design for Use on Motor Vehicles

THE SMALL DIESEL ENGINE FOR MOTOR VEHICLES, Ernest Frey. The author, who is chief engineer of the Oberursel Motor Company, claims that the chief reason why Diesel engines have not yet been adopted for use on motor vehicles lies in the fact that Diesel-engine manufacturers did not pay sufficient attention to this particular application, while motor-car manufacturers did not have the experience and knowledge of design necessary to solve the problem of designing a small Diesel engine. Inherently, however, he believes that this can be done without much difficulty.

As regards injection, either air or solid injection may be applied. Because of the greater weight of the Diesel engine as compared with the conventional automobile engine, the crankcase has to be built lighter than usual if possible. To do this, the author recommends casting the upper part of the crankcase integral with the cylinder block. The cylinders themselves should be equipped with thin steel liners.

The crankshaft should be equipped with ball or roller bearings so as to compensate for the somewhat lower mechanical efficiency of the Diesel engine. As such bearings do not have to be wide, plenty of room is available for wide connecting-rod bearings, which is important in view of the great piston pressures employed. Furthermore, for the sake of safety it is recommended that each crank have a bearing on both sides, so that a four-cylinder engine would have five bearings. This should be combined with pressure lubrication.

As regards the pistons, it is recommended that a deep depression be made toward the center of the piston head, in order to compress the air of combustion under the fuel valve which should be located as closely as possible to the center. The piston then at its upper dead center will have only a very small amount of clearance (say, 2 mm.) at its periphery against the cylinder head.

In reference to the compression pressure, it is stated that the exponent of the compression pressure curve rises with the speed of rotation; on the other hand, however, because of the small dimensions of the motor-car-type Diesel engine, the area available for heat transmission is quite large as compared with the cylinder volume. The following values of this exponent ε are recommended:

$$\text{for } n = 800 \text{ to } 1000, \ \varepsilon = 18$$
$$\text{for } n = 1000 \text{ to } 1400, \ \varepsilon = 20$$

The following valve timing is recommended: The fuel valve opens at 5 deg. ahead of the dead center and stays open until 40 deg. past the dead center; the air inlet valve opens 5 deg. ahead the dead center and stays open until 40 deg. past the dead center; the exhaust valve opens 45 deg. ahead of the dead center and stays open until 10 deg. past the dead center; and the starting valve opens 2 deg. ahead of the dead center and stays open until 120 deg, past the dead center, the cycle of operations being distributed over the four strokes in the usual manner.

Where air injection is used the design of the high-pressure compressor (whether two or three-stage) requires particularly careful attention. For the sake of simplicity the two-stage reciprocating compressor should be selected. Because of the great compression (as high as ninefold in a single stage) it is absolutely necessary to employ an efficient intercooler, which may conveniently be arranged concentrically with the high-pressure cylinder. It is also recommended that the cooler be provided at its lowest point with a drain cock or valve in order to drain off, from time to time, the oil or water that may accumulate therein. A calculation is given, indicating by means of an example how the dimensions of the compressor should be computed.

Compressed air is recommended for starting the engine. As regards the fuel pump, it is stated that this pump and its injection nozzle constitute the most important parts of the Diesel engine. In the face of numberless attempts to solve the problem, the author states that for multi-cylinder high-speed engines the only possible construction is that in which each cylinder is equipped with its own pump supplying to it the necessary amounts of fuel, no matter how small these may be.

Since the fuel pump is not capable of automatically lifting the fuel to it, it is necessary to supply the fuel from the fuel container under a small pressure, say, 0.3 atmos. gage, which pressure may be created by a separate small air pump. Care should be taken that no air gets into the suction chamber of the fuel pump, and as it is impossible to prevent small air bubbles from penetrating into the pump together with the fuel, provision should be made for maintaining a vacuum in the pump suction chamber. Above all, the pump itself must be so designed that not the slightest air bubble can persist in the compression chamber.

Fuel pumps for multi-cylinder engines consisting of one plunger and so-called distributors, which latter are supposed to take care that each cylinder gets its proper quota of fuel, have been given up as unsatisfactory. Likewise, the pumps in which the injection pressure is regulated instead of metering the fuel amounts themselves have been found unsatisfactory. Such a system of regulation even though possibly suitable for single-cylinder motors always gives an unequal fuel distribution in multi-cylinder motors, since the flow resistance in individual nozzles is never equal even when the greatest precision has been used in the production of these nozzles.

As regards the injection valves, it was found that the best results were obtained from needle valves equipped with strong springs, the methods of controlling these valves being different for solid injection from those used in air injection.

The article is to be continued. (*Der Motorwagen*, vol. 23, no. 2, pp. 30-33, 1 fig., *tp*)

THE INTERNAL-COMBUSTION LOCOMOTIVE IN STANDARD RAILWAY PRACTICE. An editorial raising the question as to why so little has been done toward the production of a locomotive operated by an internal-combustion motor for general service.

The internal-combustion engine is now fully established as an efficient, reliable and satisfactory source of motive power for stationary purposes. It has also been successful in marine work and has been applied for certain special purposes in railway traction but not in locomotives for general purposes.

There are several directions in which the large-power internal-combustion locomotive may possess distinct value in heavy railway practice. It eliminates the expensive steam boiler with its heavy maintenance costs and all the expensive appurtenances in the way of water supply and coaling-plant installations. Furthermore, no fuel expenditure is involved when the machine is not at work.

In addition to this are advantages of a directly engineering character, as for instance, the considerable power capacity which can be concentrated within relatively moderate dimensions, and the great heat and power efficiency of the well-designed modern internal-combustion engine with its reliability and freedom from breakdowns.

The editorial ascribes the lack of development in this direction to the fact that railway companies cannot undertake the necessary experimental work, while private firms have not the opportunity for experiment and trials under service conditions. The chief explanation is said to be found, however, in the actual conditions of railway traffic operation. The steam locomotive is peculiarly adaptable for variable working conditions. The internal-combustion engine requires being operated under conditions favorable to itself. Adaptations to suit speeds, gradients, light and heavy loads, etc., are easily made with steam. But the internal-combustion locomotive must either depend largely upon gearing or special transmission or be working disadvantageously whenever requirements vary much below the standard for which it is designed, and furthermore, it does not easily carry overload.

It is this elasticity in service which is so characteristic of steam-locomotive practice and which is so essential under modern traffic conditions that constitutes the greatest obstacle to the introduction of the internal-combustion engine as a practicable factor in heavy railway working. (*The Railway Engineer*, vol. 41, no. 483, Apr. 1920, pp. 138, *gc*)

LUBRICATION

Physico-Chemical Bases of Lubrication—Measurement of Oiliness—Free Fatty Acids as Affecting Lubricating Properties of Oils

THEORY OF PRACTICE OF LUBRICATION: THE "GERM" PROCESS. Discussion of the theory of lubrication, in particular the so-called "oiliness" of lubricating oils; methods of its measurement and influence of the presence of free fatty acids on the lubricating properties of oils.

The "oiliness" of lubricating oils has been observed for some time, but hitherto no methods have been found to measure it and no consistent theory has been offered to account for it.

Uebbelohde pointed out years ago (Journ.Am.Soc.M.E., June 1912, p. 963) that only a liquid which wets or spreads over the solid can constitute a true lubricant, but this did not give a basis of differentiation between various lubricants as all of them wet solids.

In order to determine the oiliness of a lubricant it would have been necessary to measure the surface tension between the oil and the solid metal bearing, which, unfortunately, we do not know how to do. Because of this, the present authors decided to measure the surface tension of the oil against the immiscible liquid in the hope that this procedure might furnish some criterion of oiliness.

The liquid selected was water and the measurements have shown several interesting facts.

In the first place, it was found that the interfacial tension of vegetable and animal oils against water is much lower than in the case of a mineral oil. Furthermore, there was a distinct difference between the tensions in the case of mineral and saponifiable oils independent of their viscosity, density, etc., and this difference appeared to be in conformity with the lubricating properties of the oils.

Further, experiments proved that the lowering of the interfacial tension against water in the case of fatty oils was due to the presence in them of small amounts of free fatty acids. In fact, it was found that when free fatty acids are removed from the saponifiable oils the tension rises, and that when they are added to mineral oils the tension can be lowered. Analyses have shown that fatty acids are present to a certain extent in practically all oils.

These experiments led to the following conclusions:

1 Capillary effects hitherto ignored in lubrication play a fundamental part
2 A neutral glyceride possesses a tension similar to that of a neutral mineral oil, and
3 The addition of a relatively minute amount of a fatty acid to a neutral mineral oil reduces the tension to that of a commercial animal or vegetable oil or compounded lubricating oil.

Interfacial tension affects lubrication in the following way: The permanency of films depends on a diminished interfacial tension between the oil and the metal in contact therewith. If such a film is broken, it will unite the faster the lower the interfacial tension.

Extensive tests were carried out to determine the behavior of various oils and it was found, for example, that 1 per cent of the free fatty acids of rape oil added to a mineral oil are as effective in reducing the value of the frictional coefficient as is the addition to the mineral oil of 60 per cent of neutral rape.

The next subject taken up in the paper is that of the colloidal characters of the fatty acids. In recent years it has been shown that while the lower members of the fatty-acid group possess relatively little colloidal character, the higher members are highly colloidal and there appears to be a gradation in these properties as one ascends the scale, lauric acid occupying a sort of intermediate position.

The fatty acids which occur in commercial oils are not pure chemical individuals, but are mixtures in various proportions of a number of fatty acids, higher or lower members predominating in accordance with the character of the oil. Thus, cocoanut oil is characterized by containing appreciable percentages of the lower members of the series, while rape oil rarely contains anything but the higher members. The behavior of the oils is determined by the fatty-acid groups which predominate in them and it is possible to reproduce the capillary properties in any particular animal or vegetable oil by adding suitably chosen fatty acids to mineral oil.

The above considerations have a practical importance. Thus, in a steam engine using saturated steam there is a tendency for condensation to occur in the cylinder and valves. In such a case the presence of a substance in the oil which lowers the surface tension against water will assist in the formation of oil films by enabling the oil to spread more readily or by reducing the tendency of the water to wash the oil film off.

In certain classes of lubrication where the oil is brought into contact with water, it may be desirable that the oil shall either separate itself rapidly from the water (demulsification), or, conversely, that it shall mix or emulsify with the water, but the emulsification is dependent upon the colloidal properties of the oil while demulsification is brought about by a greater concentration of hydrogen ions. Consequently, by varying the types of fatty acids present in the oil, it is possible to control this particular property, oils containing higher members of the fatty-acid group possessing an emulsifying tendency while the ones containing the lower members possess a demulsifying tendency.

The authors use the expression "germ process" to describe the production of oils made by using one or more fatty or other acids with one or more mineral oils. As a matter of fact, no germs whatsoever are known to have anything to do with this process.

Specifications are given for oils used in the lubrication of various classes of machinery. (Paper presented before the Society of Chemical Industry, *Journal of the Society of Chemical Industry*, 1920, pp. 51-60, T, 2 figs., *et*)

MACHINE PARTS AND DESIGN

Mechanical Reduction Gears in Warships Have "Made Good" in the British Navy

MECHANICAL REDUCTION GEARS IN WARSHIPS, Engr.-Commander H. B. Tostevin, R. N. Data on the experience and practice on this subject in British warships. Up to about 1912 only comparatively moderate amounts of power on shipboard were transmitted by gearing in the British Navy, but in the torpedo-boat destroyers *Leonidas* and *Lucifer* laid down in 1912 it was arranged to transmit the whole power, equal to 22,500 hp., through two sets of gearing. The two boats were put into commission in August 1914 and received a very severe service test, which they passed in a highly satisfactory manner.

Even before the completion of these destroyers, however, two light cruisers of 40,000 hp. were arranged to have all-geared units, one vessel with four shafts and the other with two. Both installations again proved quite satisfactory.

The paper includes a table showing the total horsepower and number of all-geared sets fitted and being fitted in warships. This total reaches the very respectable figure of 7,828,000 shaft hp.

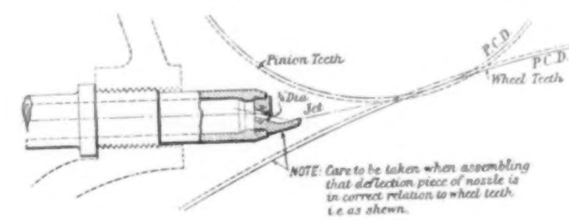

FIG. 7 SPRAYER FOR LUBRICATING GEARING TEETH

transmitted through 652 gears, the power per gearing set ranging from 1750 hp. up to as high as 36,000 hp.

As regards the gearing design, helical gearing appears to be used with the angle of obliquity of 14½ deg. Fine-pitch gears give more silent running at high speeds and a normal pitch of 7/12 in. has been adopted for all but the very largest installations. While, however, the pitch and obliquity have remained the same, the proportion between addendum, dedendum and pitch, respectively, and the shape of the root and tip have been changed from time to time with growing experience.

The question of the lubrication of the teeth is very important

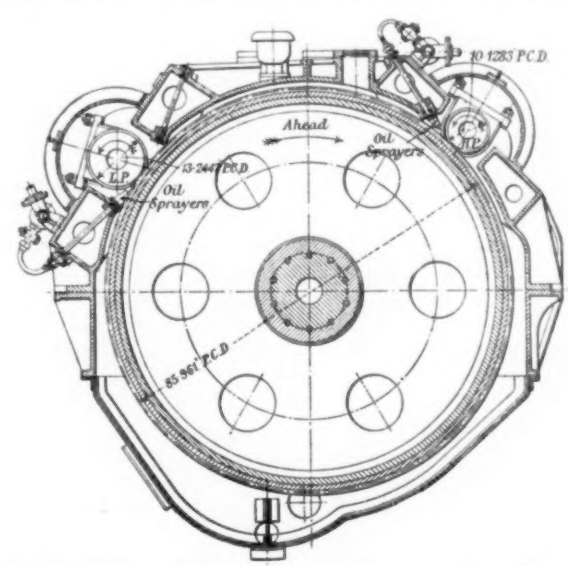

FIG. 8 SECTION THROUGH A GEAR CASE FOR A TORPEDO-BOAT DESTROYER SHOWING RELATIVE POSITIONS OF PINION AND WHEEL AND LUBRICATING ARRANGEMENT FOR THE TEETH

and oil is usually supplied through nozzles (¼ to ⅜ in., of about 5-in. pitch) discharging the oil under a pressure of from 5 to 10 lb., the jet being fan-shaped so that the whole length of the teeth is lubricated.

Figs. 7 and 8 show a type of oil sprayer fitted, together with its arrangement on the gear case.

A difficulty in the early history of gear cutting was caused by the fact that the master worm wheel which rotated the gear wheel during the cutting operation was not quite accurate; this difficulty led to an addition to the machines of a "creep" mechanism, by means of which the job is rotated at a higher speed than the table. Any recurring error in the worm wheel which might be copied

on the job being cut is, with such a machine, no longer in the direction of the axis, but is distributed in helices on the gear wheel or pinion. With improvements in the accuracy of this master worm wheel and the maintenance of the machine in good condition with all parts well lubricated during a cutting operation, the advantage derived from the use of the "creep" has been lessened, and from a list of ten firms that have cut the majority of naval gears it is a matter of interest that on the wheel machines only four, and on the pinion machines six firms, use "creep." As regards the tendency of the worm wheel to wear out of truth, inquiry has shown that in a number of machines that have been working constantly for at least three years the accuracy has not been affected.

In all naval work the turbine spindles, pinions and gear wheels are supported on rigid bearings and the alignment is determined by accurate machine work in boring the gear housings and fitting the bearings. No gears of the floating-frame type have been fitted and the system is not favored by the writer.

Several important questions which cannot be abstracted because of lack of space, are, in particular: the action between the teeth when transmitting power, the pinion and the wheel as tending to increase their distance between centers, and the speed of the teeth.

Some of the troubles experienced with gearing are described, such as, for example, the pitting of the faces of the teeth and corrosion of gears due to the use of improper lubricating oil. In an appendix an abstract from Admiralty specifications for gearing for turbines is given. (Paper read before the Institution of Naval Architects, Mar. 26, 1920. Abstracted through *Engineering*, vol. 109, no. 2832, Apr. 9, 1920, pp. 474-480, 14 figs., *dA*)

MARINE ENGINEERING (See Hoisting Machinery; Machine Parts and Design)

METALLURGY

Alloys of Oxides, Miss S. Veil. It is of interest to determine the combinations which may be formed between oxides compressed and heated according to methods analogous to those applied to metallic alloys.

The problem is both difficult and delicate in view of the slowness with which phenomena of diffusion take place between solid bodies, and the properties which can be investigated and measured with any degree of precision are few in number.

Among others, interesting results have been obtained with a mixture of oxide of chromium and oxide of cerium.

By varying the proportions of the constituent parts, the author has been able to investigate concurrently, on one hand, the electric conductivity at high temperatures, and, on the other hand, the coefficient of magnetization at ordinary temperatures.

The electrical conductivity has been measured on material pressed into the form of small rods heated in a platinum-resistance-electric furnace. The coefficient of magnetization was determined by means of the Curie and Cheneveau balance.

The results of both series of tests are presented in the form of diagrams which cannot be consistently interpreted except on the basis of admitting the existence of definite combinations between the oxides under consideration. Furthermore, while the two methods of investigation are different from each other, they give results consistent between the two.

The author indicates the different combinations of oxides which would appear to have either a certain or probable existence. (*Comptes Rendus des Séances de l'Académie des Sciences*, vol. 170, no. 16, Apr. 19, 1920, pp. 939-941, 2 figs., *et*)

MOTOR-CAR ENGINEERING (See Internal-Combustion Engineering).

POWER PLANTS

Waste-Heat Utilization in an American Steel Plant

Using Waste Heat from Furnaces, B. H. Green. Description of an installation in a steel plant utilizing waste heat from furnaces, the arrangement being such that steam derived from waste heat is supplemented by that from coal-fired boilers and used for electrical power generation.

The waste heat is obtained from ten 75-ton open-hearth furnaces fired with producer gas or tar. The furnaces each deliver at the boiler an average of 65,000 lb. of waste gas per hour at a temperature ranging from 900 to 1300 deg. fahr., but averaging

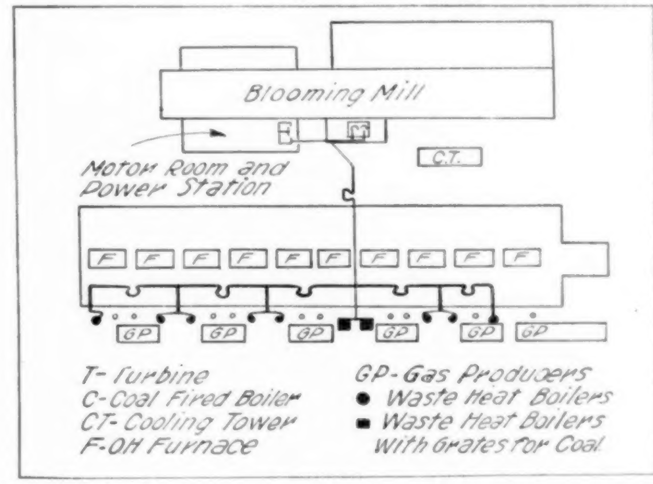

Fig. 9 Plan Showing Location of Waste-Heat Boilers in an Open-Hearth Steel Plant

fairly well around 1100 deg. during weekly operation. The open hearths are shut down over Sundays and because of this little steam is generated on Mondays and Tuesdays, the output increasing until the maximum is reached on Thursdays and Fridays.

The boiler plant had to be fitted into the existing steel-plant operation, the available space for the boilers being very limited indeed. Fig. 9 shows how this problem was solved. Vertical two-pass boilers (Wickes type) were installed, as in this particular location the arrangement in this type of boiler permitted a

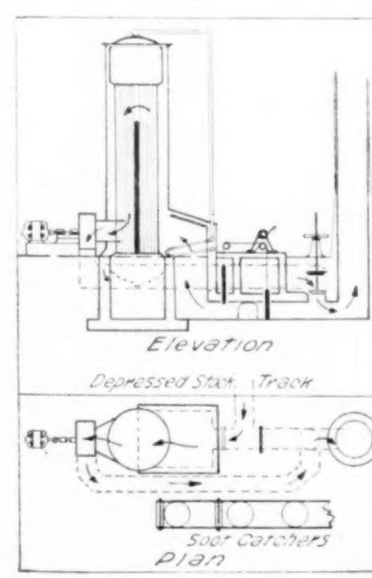

Fig. 10 Plan and Elevation Showing Arrangement of Units in Large Boiler Plant and Vertical-Sliding Waste-Gas Valves Used at the Boilers

shorter gas travel between the furnace and boiler. A total space width of about 16 ft. was all that was available for the boilers between the gas-producer soot catchers and a depressed stock track, and Fig. 10 shows how this location was utilized.

There were other problems that had to be considered in de-

termining the location of the boiler. Thus it was desirable to keep the stack warm and to allow its draft to assist the induced-draft fans used in connection with the boilers.

Fig. 10 also illustrates the type of vertical-sliding water-gas valves used at the boilers. These valves are two in number and counterbalance each other as shown, thus rendering the raising or lowering a comparatively easy matter for one man on the winch. A 4-ft.-diameter saucer valve with vertical screw arrangement is also used to shut off the boiler gas passage at any time when the boiler is shut down and the furnace is discharging directly into the stack.

The boilers averaged 250 boiler hp. each during actual operating hours after the initial troubles had been overcome.

The fans have a capacity of from 75,000 to 80,000 lb. of gas per hour when running at a speed of about 600 r.p.m. and produce a draft of 4 in. of water with a gas temperature of 450 deg. at the fan breeching, which gives a draft of about $1\frac{1}{4}$ in. at the furnace valve damper. The boiler fans should be of sturdy construction with substantial bearings and shafts, as in this location, among the gas producers, great quantities of fine ash sift in through every conceivable crack. Heavy rigid bearings were adopted with substantial dust collars applied externally and clamped tightly so as to hold the felt rings snugly against the shaft. The shafts were made of large size, in order to avoid damage due to possible warping or bending of the fan wheel by reason of heat or by the accumulation of ash on the blading of the fan, which would tend to produce unbalancing. All fan bearings are water-cooled.

Gas explosions are experienced occasionally in the boilers upon reversal of the furnaces, but it has been found that these can be avoided to a great extent by the careful handling of the reversing valve by the furnace operator. It is possible that a careful timing of throw-over of gas and air valve with relation to each other might eliminate explosions entirely by allowing either the free air or the unburned gases to escape into the boiler alone and not in an explosive mixture of the two together.

The original article describes also the auxiliary coal-fired boilers and the piping used in the plant. (Paper before the Cleveland Section of the Association of Iron and Steel Electrical Engineers. Compare the *Iron Trade Review*, vol. 66, no. 15, Apr. 8, 1920, pp. 1065-1068, 3 figs., *d*)

COAL PULVERIZERS. Description of the Aero-Pulverizer, a self-contained unit which first reduces coal to the requisite degree of fineness for burning in furnaces and then feeds it into the furnace.

The advantages of such a unit are that the coal is used as soon as it is powdered and no provision has to be made for storage, and that unless the raw coal is excessively wet it does not need to be dried prior to grinding. It is claimed that it can be ground with a moisture content as high as 6 per cent.

As shown in Fig. 11, the casing is divided into compartments, the number of which varies with the size of the plant. In each compartment there revolves at high speed a disk paddle equipped with a series of hard steel paddle blades. The paddles are all keyed to one horizontal shaft passing from end to end of the machine. The final compartment contains a series of fine blades which revolve with the shaft carrying the paddles. At the end of the machine, remote from the fan, there is an adjustable air inlet, and the amount of air sucked in through the fan and hence the fineness of the dust delivered from the pulverizer are determined by altering the area of the orifice at that inlet. The coal is fed into the pulverizer from a hopper in the form of a sleeve and the amount can be regulated by simply raising or lowering the sleeve.

The diameter of the paddles and their blades is somewhat less than that of the compartments in which they revolve, there being about $\frac{5}{8}$ in. clearance all around. There is therefore no grinding action between the blades and the casing, the pulverizing being done entirely by a beating or impact action. As more coal is fed into it the first compartment is gradually filled until the partly powdered coal overflows the division piece into the second compartment, and so on to the last. During the whole process air is being sucked through the machine by means of the fan and the most finely ground coal is carried away by the current. This is the reason why the strength of the current determines the fineness to which the coal is ground.

A small compartment can be seen on the hinged back casing between the three pulverizing compartments and the fan compartment. It is for the purpose of admitting more air to the

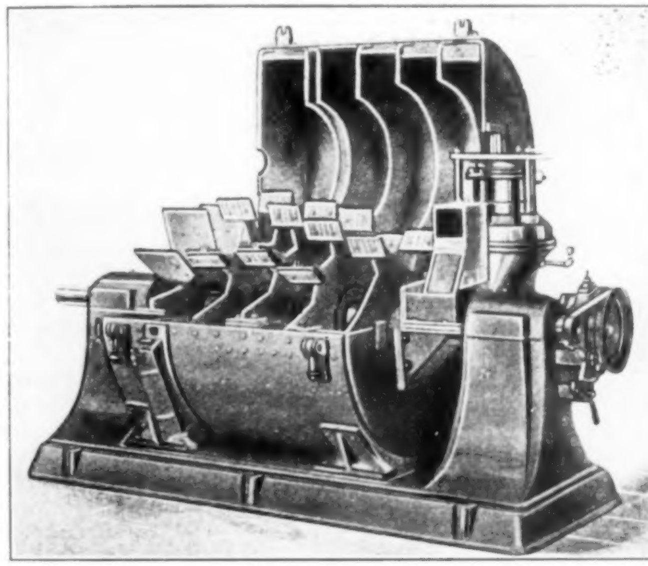

FIG. 11 AERO-PULVERIZER, A COAL-PULVERIZING AND FEEDING MACHINE

apparatus, this additional air serving the purpose of carrying the powdered coal into the distribution system to support combustion of the coal. It is claimed that this machine has been successfully employed for the firing of the furnaces of various types as well as water-tube boilers. (*The Engineer*, vol. 129, no. 3351, Mar. 19, 1920, pp. 306-307, 3 figs., *d*)

POWER TRANSMISSION

Constantinesco Sonic Waves, Their Nature and Application—Power Transmission by Rapid Impulses in Liquids

POWER TRANSMISSION BY SONIC WAVES, J. Herck. Description of the Constantinesco system of power transmission.

All methods of power transmission may be divided into three basic classes: First, rigid transmission from solid body to solid body, as in gearing, belt and other friction-drive methods; next, transmission by fluid under pressure, no matter what the nature of the fluid may be—water, air or even electricity (direct current); third, the so-called "sonic" waves of M. Constantinesco, a Roumanian engineer, who is said to have spent close to twenty years in experimental work connected with the development of his idea.

The employment of sonic waves is based on experimental work which is said to have demonstrated that, contrary to popular impression, liquids are essentially compressible.

Let us consider a conduit having a piston at each end, A and B, and entirely filled with a liquid, the pistons being leak-proof. If, now, the piston A is given a sudden impulse the liquid will be compressed, the volumetric compression storing up in the liquid a quantity of energy proportional to the coefficient of elasticity of the liquid. Furthermore, since the deformation produced is assumed to have been sudden, a wave is created in the liquid and moves through it with a velocity equal to $\sqrt{(E/m)}$, where E is the coefficient of elasticity of the liquid and m the mass per

unit of volume. This velocity is the same as the velocity of propagation of sound in the given liquid.

If the length of the conduit be properly selected, the wave will cause the piston *B* at the other end to move, and if a vibratory motion be imparted to the piston *A*, the piston *B* will receive the same motion, the conditions being somewhat analogous to what takes place with single-phase alternating current in electricity.

The intercalation of an auxiliary reservoir creates a capacity having the same effect as a condenser in an electric circuit; a spring in the circuit, by its inertia, performs the same functions as a self-induction coil, and resistance in the conduit to the passage of the wave reminds one of an electric reactance, while the average pressure produced may be compared to the voltage in an alternating-current circuit.

The analogy between sonic waves and transmission of power by alternating current can be carried still further. If we take three conduits that are interconnected and have impulses spaced 120 deg. apart, we obtain three waves spaced likewise 120 deg. apart and have something similar to three cables carrying the three-phase alternating current—in this case only sonic instead of electric. All that is necessary to create it is three pistons placed star-wise, while at the receiving end two arrangements may be employed, depending on whether it is desired to have a synchronous or asychronous motor.

It is interesting to note further that the transmission of energy in sonic waves is governed by laws remarkably analogous to such laws of electric circuits as Ohm's law, Joule's law, etc.

The Constantinesco principle has been applied for numerous purposes during the war when the inventor was working for the British Admiralty. Among these may be mentioned the hydraulic hammer with the "single-phase" sonic motor; another type of hammer for chipping stone; drills with two-phase asynchronous sonic motors; servo-motors for use on aeroplanes, which are very powerful for their small size; and what is of particular interest, a device for oil injection on Diesel engines. This device has been applied by the British Admiralty to a 1000-hp. Diesel engine and is said to have given entire satisfaction.

Another interesting application of the same principle has been made in connection with bomb throwers capable of hurling a bomb weighing 220 lb. to a distance of close to 5000 ft., and that without either fire or noise. In this device the energy of a small cordite cartridge is absorbed in the compression of a liquid which restores it by pushing the bomb under constant pressure over the entire length of the gun barrel, this affecting the efficiency of the explosion very favorably.

It is stated that experimental work is being carried on to apply the same principle to the power transmission between the engine and propeller of an aeroplane.

The best-known application of the Constantinesco principle is that of synchronizing the propeller and the machine gun on aeroplanes, extensively used by the Allied armies during the recent war. (*Bulletin Technique du Bureau Veritas*, vol. 2, no. 4, Apr. 1920, pp. 69-73, 5 figs., *d*)

RAILROAD ENGINEERING

NEW TEN-WHEEL HELPING ENGINE ON THE MIDLAND RAILWAY, ENGLAND, Frederick C. Coleman. Description of a locomotive of a new type recently built at the Derby Works in England. It has four cylinders, each $16\frac{3}{4}$ in. diameter by 28 in. stroke, cast in pairs, one steam chest to each pair. In these cylinders cross-ports have been introduced which makes it possible for one piston valve to supply both cylinders on one side of the engine. The front piston-valve head serves the front port of the outside cylinder and the back port of the inside cylinder, and vice versa.

Owing to severe gradients on the road all the wheels are braked, the front three pairs being operated by a steam cylinder and shaft placed just behind the driving axle, and the two hind pairs of wheels by a cylinder and shaft placed under the draft casting. In addition a hand brake has been fitted on the engine to act on all wheels. (*Railway Review*, vol. 66, no. 16, Apr. 17, 1920, pp. 657-658, 1 fig., *d*)

REFRACTORIES

THE POROSITY AND VOLUME CHANGES OF CLAY FIREBRICKS AT FURNACE TEMPERATURES, Geo. A. Loomis. This paper deals with the permanent changes in porosity and volume of clay firebricks when reburned to temperatures at or above those to which they were originally fired. These were measured for a series of temperatures to determine what relation, if any, might exist between these changes and the deformation of the same bricks under load at furnace temperatures. The possibility of such a relation is suggested by the fact that contraction of clay on heating and decrease in porosity are, to a certain extent, indications of the amount of softening of the mass due to the action of fluxes present, and hence indicative of decreased resistance to deformation under pressure or decreased viscosity. Softening-point determinations were also made to determine what relation these might bear to the results of the load test.

The results of tests on a large number of clay firebricks from various parts of the country show that bricks which withstand a load test of 40 lb. per sq. in. at 1350 deg. cent. without marked deformation, show no marked changes in porosity or volume up to 1425 deg. cent. Bricks which do not withstand the test generally show appreciable contraction or expansion, accompanied by considerable decrease in porosity. Bricks which showed overburning and the development of vesicular structure below 1425 deg. cent. by marked expansion or increase in porosity, invariably failed under load. In general, bricks which show a decrease in porosity exceeding 5 per cent or a volume change exceeding 3 per cent (amounting to approximately 1 per cent in linear dimensions) when refired to 1400 deg. cent. fail to pass the load test.

No definite relation could be determined between the softening point of a brick and its ability to withstand pressure at high temperatures. All bricks softening below cone 28 failed completely in the load test. Some showing quite high softening points also failed, probably due to the use of an inferior bond clay in the mixture or too small an amount of bonding material. (Abstract of *Technologic Paper of the Bureau Standards*, No. 159, *e*)

REFRIGERATION

Biological Phenomena in Fruits and Meats in Cold Storage

SCIENTIFIC PROBLEMS OF COLD-STORAGE INDUSTRIES, W. B. Hardy. The author, Secretary of the Royal Society and Director of Food Investigation, discusses the wider biological aspect of food preservation. Essentially, food preservation by means of cold storage means an attempt to stop certain organic processes which would otherwise lead to the decomposition of the food.

It appears, however, that while this is being achieved other processes may be initiated and ultimately lead to undesirable changes in the properties of the foods. The author expresses this by saying, in particular in reference to fruits and vegetables, that if these latter are to be preserved in any semblance of their normal selves they must be kept alive, and their preservation as living organisms must in principle depend on the selection of some agent which will lengthen the normal duration of their life.

An apple, like every portion of living matter, is an internal-combustion motor constructed to work over a rather remarkably large range of temperature. It is true that the moving parts are small, being, in fact, chemical molecules. Once plucked, an apple is like a clock wound up and will go only for a certain period. It will die when the chemical changes it is wound up to perform are completed and will also die if the normal progress of those chemical changes is interfered with sufficiently.

To lengthen the duration of the life of a fruit, we take advantage of two features of living matter considered as a machine, namely, the temperature coefficient of the vital processes, and the fact that its rate of working is determined within limits, first by the supply of oxygen and next by what an engineer might call the back pressure of the products of its own chemical changes. The temperature coefficient is of the same nature as that affecting a large number of chemical changes where the processes are being

retarded within limits by cold and accelerated by heat. Hence the use of cold storage to keep fruit.

The final products of chemical changes in living organisms are carbonic acid and water. If the analogy between living matter and an internal-combustion engine is sound, prevention of escape of the carbonic acid should, broadly speaking, produce in fruit an effect comparable to that produced when the free escape of the exhaust from a gasoline engine is hindered. The engine is slowed down, and this is what actually happens to fruit. Apples or other fruit placed in a chamber from which the carbonic acid cannot escape do actually ripen much more slowly than similar apples placed where there is free escape. The combustion motor may also be slowed down (and the ripening of fruit delayed) by diminishing the supply of oxygen, and this is the scientific principle which underlies the familiar practice of pitting potatoes. However, interference with normal processes brings about a train of new phenomena.

If the exhaust of an internal-combustion engine is choked or if it is starved of air, the whole series of chemical changes which occur in the cylinder are modified, as our sense of smell informs us. Fruit behaves in precisely the same way. If its normal respiration is interfered with, the intrinsic chemical changes are not merely delayed but modified and may be modified to such an extent as to render the fruit totally unfit for an article of food. Combustion in the fruit, as in the gasoline engine, is incomplete. In the former, the products of incomplete combustion take, among other things, the form of alcohol. Thus, strawberries preserved in this way are apt to develop amyl alcohol and in such quantities as to give them the flavor of a pear drop.

The cold storage of meat is discussed by the author from the same biological standpoint. (*The Cold Storage and Ice Association*, vol. 16, no. 1, 1919-1920, pp. 23-35 and discussion 36-45, *tA*)

THERMODYNAMICS

New Thermodynamic Cycle Applicable to Internal-Combustion Engines

NEW THERMODYNAMIC CYCLE, Wm. J. Walker. Description of a thermodynamic cycle especially applicable to internal-combustion engines.

The author claims that the usual cycles based on the formula

$$\text{Thermal efficiency} = \eta_t = 1 - \frac{1}{r^{\gamma-1}} \ldots\ldots\ldots\ldots [1]$$

where r is the adiabatic compression ratio, give an impression that engine efficiencies are limited wholly by the compression ratios with which they operate, which is not necessarily always the case.

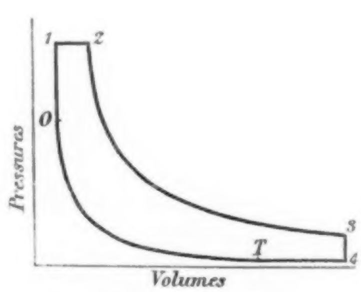

FIG. 12 DUAL COMBUSTION CYCLE FOR INTERNAL-COMBUSTION ENGINES

In the present investigation the thermodynamic cycle shown in Fig. 12 has been chosen to represent the most general type. Cycles of this type are termed by the writer "dual combustion cycles," on account of the fact that the heat is imparted to the working fluid by internal combustion both at constant volume and constant pressure. The problem which the writer considers is the determination of the maximum efficiency condition for a cycle comprised between given pressure and volume limits, assuming heat to be supplied either at constant volume, constant pressure, or both.

The operations concerned in the cycle of Fig. 12 are:

From T to 0, adiabatic compression
From 0 to 1, heat given at constant volume
From 1 to 2, heat given at constant pressure
From 2 to 3, adiabatic expansion
From 3 to 4, rejection of heat at constant volume
From 4 to T, rejection of heat at constant pressure.

The efficiency of the cycle is given by

$$\eta_t = 1 = \frac{\text{Heat rejected}}{\text{Heat received}}$$

$$= 1 - \frac{(T_3 - T_4) + \gamma(T_4 - T)}{(T_1 - T_0) + \gamma(T_2 - T_1)}$$

After several operations the author obtains the following equations:

$$\eta_t = 1 - \frac{A - \gamma^r}{B - r^\gamma} \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

and

$$(\gamma - 1)r^\gamma - Ar^{\gamma-1} + B = 0 \ldots\ldots\ldots\ldots\ldots\ldots [3]$$

where A and B are defined by

$$A = c^{\frac{1}{\gamma}}\left\{\rho^\gamma + (\gamma - 1)\right\}$$

and

$$B = c\left\{1 + \gamma(\rho - 1)\right\}$$

and c is a constant for given pressure limits and is equal to ar^γ.

The solution may be obtained either graphically from Equation [3] or by curves from Equation [2] showing the relationship between η_t and r for different values of ρ. These curves are shown in Fig. 13, the value of γ being taken as 1.3.

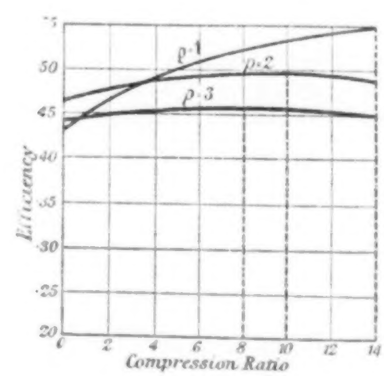

FIG. 13 CURVES SHOWING THE RELATIONSHIP BETWEEN THERMAL EFFICIENCY AND ADIABATIC COMPRESSION RATIOS FOR DIFFERENT ENGINE TYPES

The curve where $\rho = 1$ is the efficiency curve for the Atkinson cycle. The author points out, however, that this cycle is the limiting case of a series of cycles, all of which have a definite maximum efficiency at a compression ratio less than the compression ratio required to compress the gases to the maximum pressure of the cycle. (*Engineering*, vol. 109, no. 2832, Apr. 9, 1920, p. 467, 2 figs., *tA*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

MECHANICAL ENGINEERING
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Contributions of interest to the profession are solicited. Communications should be addressed to the Editor.

On the date when this number of MECHANICAL ENGINEERING is issued, the Spring Meeting of the A.S.M.E., for which its members and friends at St. Louis have made such careful preparation, will have been concluded and a goodly number, it is hoped, will be en route to Tulsa for the meeting in that city and the inspection of the great oil fields. An account of both meetings will appear in MECHANICAL ENGINEERING for July. Long may the memories of these meetings linger in the minds of those who are so fortunate as to attend!

Standardization of Screw Threads

The Congressional Screw Thread Commission, an abstract of whose report appears elsewhere in this number, has accomplished a fine piece of standardization work worthy of the careful consideration of all manufacturers of machinery. The Commission has adhered to the recognized thread standards already in use in this country, namely, the United States standard and A.S.M.E. machine-screw standard for coarse threads; the S.A.E. standard for fine threads; the Briggs standard for pipe threads; and the standards recommended by the National Fire Protection Association and the Bureau of Standards for fire-hose threads.

It is well and good to specify standardized sizes and forms, but such are of very little avail unless means are provided for the carrying out of these standards in practical industrial work. It is here, therefore, that the chief value of the Commission's efforts are to be found. A great deal of the report is devoted to the question of tolerances and the subject of gaging. Every effort has been made to establish tolerances which are reasonable and workable, and the Commission has gone to the extent of recommending different limits for screw threads for different classes of machinery, ranging from the heavy and more crude machines to the light and delicate types requiring the finest workmanship.

It is due to the Commission that a fair trial of these tolerances be made by manufacturers, as only by such earnest coöperation can the industries of the country derive the benefit which is sure to come to them if workable screw-thread standards can be brought into general use.

Members of the A.S.M.E. are acquainted with the painstaking work previously accomplished by their own committee on screw thread tolerances; and it is a pleasure to know that this committee's investigations were extremely useful in the Screw Thread Commission, particularly in the facts which they brought out with respect to the influence of variations of lead on screw-thread fits, which are equally as important in determining limits as the question of variations in pitch diameter.

Modern Coast Defenses

The naval and coast-defense problem of this country receives considerable light from the description of one of the most powerful coast defenses in the world given by Lt-Col. H. W. Miller in this issue's leading article. The fact that the Allied fleet with all its strength was not able to reduce the German batteries after three years' bombardment proves again the superiority of land fire over gun fire from floating vessels, while the extensive use of anti-aircraft guns prevented the accurate dropping of bombs. The location of the large batteries at considerable distance from the shore increased the difficulty of the already difficult problem for the naval gunner of hitting a target of low visibility from an unsteady platform. The adoption of railway mounts and use of smoke screens for coast defense by the Germans for their Belgian fortifications are points that can well be used by the engineers who will lay out the future coast defenses of this country. The simplicity of construction and scheme of location of these defenses are also important to the United States.

Special Bulletin on Society Affairs

A part of the matter which ordinarily would have been contained in Section Two of this number of MECHANICAL ENGINEERING, including the Positions Available of the Employment Bulletin, has been issued to the membership of the A.S.M.E. ten days in advance of the publication date of this Journal, in the form of a special bulletin. The reason for this is explained in a brief article in the bulletin referred to under the heading "How Do You Like It?" which is quoted herewith.

A "speed up the service" policy has been advocated by the Committee on Local Sections of the A. S. M. E. and backed by the Council. There are many things about the work and accomplishments of the various committees of this and other societies which you as a member ought to know about and *know about promptly*. Part Two of MECHANICAL ENGINEERING, issued each month, tells the story but does not tell it soon enough. It requires nearly a month to publish and distribute a journal of the size of MECHANICAL ENGINEERING. In the case of the Employment Bulletin particularly this is a serious matter. Those seeking positions are entitled to prompt advice about new openings. By means of a small Bulletin like the present one, issued occasionally to supplement Part Two of the regular Journal, this much-to-be-desired quick news service can be given. This first copy of the proposed Bulletin has been brought out at the request of the Committee on Local Sections as a "Spring Meeting Special," and for the purpose of trying out the idea among the membership.

Would you like to have it continued—occasionally?

Write the Secretary.

James W. See—An Appreciation

Few of the younger generation know much of one of the outstanding figures in the world of mechanical engineering and one of the most appreciated members of our American Society of Mechanical Engineers. The main facts of Mr. See's career are correctly enough given in the condensed biography in the April number of MECHANICAL ENGINEERING; but were that biography expanded a thousand fold, as it might well be, it would still remain but a cold recital did it not take account of Mr. See's, or, to give his old nom de plume, Chordal's essential humanity, clear-headedness and logic so rarely found coupled, as they were with him, with an underlying kindness that was always at the disposal of any seeker for help. The writer for one will never forget when, in his early days, many a problem that appeared to him

almost unsolvable before he took it to Chordal, became so apparent after a few minutes' talk, that he was invariably surprised at himself for thinking it at all abstruse or difficult; yet never did Chordal convey the impression of imparting information. Recalling this in later years, after a riper experience, the writer is convinced that See had that quality of ingrained common sense that penetrates at once and with no apparent effort to the root of any problem. All those who were privileged to come into personal contact with See, and there were many, felt that, even though their ways might have diverged widely over the years, with his passing the world, and not only the engineering world, had lost one of its kindliest and most helpful figures.—HENRY HESS.

Engineering Foundation Seeks Large Endowment

The Engineering Foundation, created by an endowment of $300,000 from Ambrose Swasey, past-president and honorary member of The American Society of Mechanical Engineers, is now actively seeking additions to this endowment which will raise the total to at least a million dollars.

Through Mr. Swasey's generous gifts the Foundation has maintained since 1915 a liaison between engineers, as represented by the founder and other societies, and scientific workers, as represented by the National Research Council. Practical means for coöperation in research thus exist for the engineers in the numerous branches of the profession to join with the workers in other fields of science, in the attack upon problems of common interest and in the exchange of knowledge.

Engineering Foundation seeks to build up its endowment to dimensions worthy of the profession, for progress will be made approximately in proportion to the funds available. Besides problems relating to the materials and forces of engineering, many acute social and economic questions of our day need the patient study of scientists and technologists.

It is the purpose of the Engineering Foundation to stimulate, coördinate and support research work in existing scientific and industrial laboratories, coöperating, in so far as may prove advantageous, with the National Research Council. It does not plan to build laboratories and conduct research work directly.

Mr. Charles F. Rand, past-president of United Engineering Society, and of the American Institute of Mining and Metallurgical Engineers, is chairman of Engineering Foundation.

The office of the Foundation is in Engineering Societies Building, 29 West 39th Street, New York, and further information may be had by addressing that office. A booklet giving an account of the Engineering Foundation and its work will be mailed upon request.

The Engineering Index for 1919 Just Issued

The 1919 annual volume of The Engineering Index, the first to be compiled by the staff of The American Society of Mechanical Engineers, is now ready for distribution. This year's volume is a book of 528 pages and contains over 12,000 references to the engineering and allied technical publications of the world. These have been selected from over 700 periodicals representing some twelve languages, thus making the index a comprehensive guide to the engineering literature of 1919.

In addition to containing more references than any previous annual volume, the items of this year's Index are arranged in alphabetical or dictionary form, instead of being grouped under the divisions of engineering as has heretofore been the custom. This feature makes it possible for one to turn directly to the subject claiming his particular attention, instead of being put to the necessity of first classifying it as civil engineering, electrical engineering, mechanical engineering, etc. The price of the work is $4.

The Engineering Index is the continuation of a work started in 1884, when Prof. J. B. Johnson, of Washington University, St. Louis, began to regularly index for the Journal of the Association of Engineering Societies the articles appearing in the leading current periodicals of that time. The undertaking proved highly successful, and at the end of five years Professor Johnson compiled and published the first volume.

As the work developed it seemed advisable to combine it with a somewhat similar service then being rendered by the Engineering Magazine Company (New York), and accordingly in 1895 the second volume, while edited under the direction of Professor Johnson, was published by that concern. From then on until the close of 1918 The Engineering Index was regularly published by the Engineering Magazine Company.

During these years the Index was greatly enlarged in its scope and the number of periodicals indexed was increased to about 240. At the close of 1918 The Engineering Index was acquired by The American Society of Mechanical Engineers. It was combined with the Selected Titles of Engineering Articles then appearing in the Society's monthly Journal, and the number of periodicals indexed increased threefold. The Index is a regular feature of MECHANICAL ENGINEERING.

Resignation of Dr. Manning as Director of Bureau of Mines

Dr. Van H. Manning, Director of the Bureau of Mines, Department of the Interior, resigned on June 1 to become Director of Research of the recently organized American Petroleum Institute, the most important body of petroleum men of the country. In his letter of resignation to President Wilson, Dr. Manning said:

> In leaving the Government service there comes to me, as it has over and over again, the thought that although this Government spends each year many millions of dollars in useful scientific work for the benefit of the whole people, the monetary recognition of its scientific and technical servants is not sufficient to enable them to continue in the service for the people. This has been especially true within the last few years when it has been impossible for many men to remain in the Government service.
>
> With the marvelous expansion of the industry in this country and the growing necessity of science to industry, the scientific bureaus have been utterly unable to hold their assistants against the competition of industry which is taking their highly trained men at salaries the Government does not pay or even approach.

These words of warning bring out prominently the serious handicap under which the work of the Governmental departments is now being carried on. There is no more pressing need under the present conditions of unrest than the stabilization at least of the departments of the Government where accomplishment is dependent upon the maintenance of a strong organization.

In regard to Dr. Manning personally and his connection with the Bureau of Mines, Prof. O. P. Hood, chief mechanical engineer of the Bureau of Mines, writes as follows and it is a pleasure to publish this testimonial from one of Dr. Manning's most prominent associates:

"Mr. Manning's handling of the Bureau's work has been characterized by administrative energy and decision. His habit of quick decision has kept things moving. There has been no radical change of policy in the Bureau's objectives but a steady healthy growth and enlargement of fields of usefulness. The Petroleum and Natural Gas Division has been largely developed during his administration, and the new work which he enters is but a continuation of similar effort.

"Mr. Manning has greatly developed schemes of coöperation with individuals and industries whereby governmental and private organizations having the same objectives in research, work together and make available to the public information which would otherwise be had by few.

"His foresight in marshalling the chemical investigators of the country around a small section of the Bureau's work when chemical warfare was forced upon us is characteristic. What finally developed into the Chemical Warfare Service was initiated and administered for fifteen months as a part of the Bureau of Mines. Similar foresight and energy was shown in utilizing the Bureau for war-time service in several fields.

"His methods of management have been such as to win the loyal support of the technical and administrative men who regret to see him leave, but who rejoice that he finds more remunerative work."

Dr. Frederick G. Cottrell, the new director succeeding Dr. Manning, became connected with the Bureau of Mines in 1911 and during the past year has been assistant director. Several years ago he evolved what is known as the Cottrell process for the electrical precipitation of fume and fine particles suspended in the gases from metallurgical furnaces and cement works. This process has been applied successfully in many large plants in different parts of the world. In a desire to encourage scientific research, Dr. Cottrell turned over his patent rights to a non-dividend paying corporation, known as the Research Corporation, a body formed for that purpose. A fundamental requirement in the incorporation is that all net profits shall be devoted to the interests of scientific research.

Aside from his work on smelter smoke Dr. Cottrell has been deeply interested in and intimately connected with work on the separation and purification of gases by liquefaction and fractional distillation. During the world war and subsequent thereto the development of the Norton or Bureau of Mines process for the recovery of helium from natural gas has been his special care, and it was chiefly through his efforts that a plant for recovering helium on a large scale for military aeronautics has been erected near Petrolia, Texas.

Cruising Radius of Aeroplanes

In view of the somewhat loose talk of crossing the Pacific by aeroplane in a non-stop flight, it may be of interest to call special attention to the recent paper by Dr. A. Rateau, Hon. Mem. Am.Soc.M.E., in the May issue of MECHANICAL ENGINEERING and the report made by Dr. J. Coffin to the National Advisory Committee for Aeronautics, of which a brief abstract (preliminary to publication in the Annual Report of the Committee) appears in the present issue.

The two investigators came to values which do not materially differ from each other. Doctor Rateau investigates the question of maximum cruising radius more directly than does Doctor Coffin, and the conclusion to which he comes is that an aeroplane of the present type with a non-supercharged engine can cover 5000 km. or 3100 miles certainly, 6000 km. or 3700 miles possibly, but that it is very doubtful whether it can fly 7000 km. or, say, 4350 miles.

Even these cruising radii, however, are predicated on the condition that the flight should occur very near the ceiling of the given aeroplane, which means at altitudes ranging in the proximity of 20,000 ft. We are all familiar from the experience of Major Schroeder and of Rohlfs with the discomforts of flight at very high altitudes and it is rather difficult to expect that a flier would have the endurance to remain for a period of many hours at a stretch at these extremely high altitudes without the artificial stimulants or artificial protection from the elements which hitherto have alone made possible high-altitude flying.

It should borne in mind in this connection that the figures of Rateau are based on the assumption that the aeroplanes would not carry a single pound of weight not absolutely necessary for the purpose of covering the greatest possible distance. The presence of oxygen tanks or similar devices would mean materially added weight and would cut the cruising radius to a corresponding extent. Enclosed compressed-air chambers for aviators would also cut down the cruising radius, though in ways different from the addition of compressed-air tanks. It would therefore appear that with the Brown and Alcock flight from Newfoundland to Ireland across the Northern Atlantic, we have already come fairly close to the maximum practical range of the present aeroplane and can look forward to increasing it only through essential changes in the construction of either the aeroplane or the engine, or possibly through the development of a fuel of greater heat capacity than any we have at our disposal today.

An important limitation to the formulæ developed by Doctors Rateau and Coffin for the maximum cruising radius of aeroplanes, is that they apply only to flight in calm air.

The remarkable high-altitude flights of Major Schroeder and of Rohlfs have shown that the air at high altitudes is anything but calm. The flights of Major Schroeder have indicated the prevalence of steady "trade" winds of unsuspected velocities, rising to possibly as high as 200 miles per hour, or even more, and it has been stated that the War Department was planning to send a dirigible from San Francisco to the Eastern seaboard, utilizing these high-velocity winds to accomplish the transcontinental trip in what has been estimated to be from eight to ten hours.

It is obvious that if such should be the case and the winds be relied on for carrying the airships,—whether heavier or lighter than air is immaterial at such tremendous speeds,—the cruising radius would be correspondingly extended. It would consequently appear not impossible to cross from San Francisco to London in the air in a period no longer than taken by special trains to carry a passenger from Chicago to New York by rail.

John Fritz Medal Presented to Orville Wright

On May 7, the sixteenth presentation of the John Fritz Medal was made to Orville Wright, Hon. Mem. A. S. M. E., for noteworthy work in the development of the airplane. The ceremony took place in the auditorium of the Engineering Societies Building, Charles F. Rand, former president of the United Engineering Society and past-president of the American Institute of Mining and Metallurgical Engineers presiding in the absence of Benjamin B. Thayer, past-president of the American Institute of Mining and Metallurgical Engineers and chairman of the board of award.

The first speaker was Major General George O. Squier, Chief Signal Officer, U. S. A., who as an officer of the Signal Corps in 1908 presided over the board of officers that prepared the specifications and supervised the acceptance tests of the Wright planes, and in this connection became very closely connected with the Wright brothers. He related the incidents connected with the first flights at Fort Myer and gave the history of the first Wright flights abroad. He paid tribute to the concentration and thoroughness, reticence of speech and capacity for work of the two Wright brothers and called attention to the fact that these characteristics made them great as engineers. He made it clear that the painstaking pioneer work of the Wright brothers furnished the foundation for the rapid and sure development of the airplane and in closing saluted Mr. Wright as the most distinguished engineer in the world.

Edward A. Deeds, former Colonel in the Signal Corps, member of the Aircraft Production Board and a lifelong friend of the Wright brothers, told of the early work of the two boys in Dayton, in a delightfully informal and intimate way. He spoke of their inspirations, their early successes and especially their failures, which made it necessary for them to develop by laborious research the first basic theory for their future work. He dwelt on the thoroughness with which the design of their first planes was consummated, with the result that present designs differ little from the originals of the Wright brothers. In closing he spoke particularly of the remarkable team work with which Wright brothers worked and risked their lives, and of the wonderful sacrifices made by the entire Wright family, to the end that man might fly.

In presenting the medal, Comfort A. Adams, past-president of the American Institute of Electrical Engineers, said in part:

"It is with particular pleasure that we honor one who, through years of patient, painstaking and discouraging research, in the face of almost insuperable obstacles visited with danger to life and limb, finally succeeded in developing a machine that would actually fly. We wish you to know that we are not unmindful of that other whose life was sacrified in this cause, and that, in spirit at least, this medal is awarded to the Wright brothers."

Mr. Wright responded very briefly, expressing his especial appreciation at the receipt of this mark of great honor from the engineers of the country.

Government Activities in Engineering

Notes Contributed by The National Service Department of Engineering Council[1]

Senate Considering Water Power Bill

The Water Power Bill was reported back to the Senate and House after agreement by the conferees and the House promptly accepted the conference report after a short debate by a decisive vote of 259 to 30. In the natural course of events this practically assured the early passage of the bill into law but quite a formidable filibuster has developed in the Senate. It now appears that the bill is in serious danger unless the conferees make further changes in it.

The filibuster, it is understood, will be led principally by the Senators from New England who object to the implied federal control of business. It will be recalled that the bill has had a treacherous path through many sessions of Congress and that it was lost by a narrow margin in the filibuster and legislative jam that came at the end of the last session. Those in favor of the measure, however, are in hopes of forcing a vote and bringing the measure to favorable final action before Congress adjourns.

It will also be recalled that after the passage of this bill by both Houses considerable delay resulted in conference, due to the inability of the conferees to agree on points of difference concerning principally the appointment of an executive secretary, definition of navigable waters, and limitations for awards on severance damages incurred on recapture of property at the end of the fifty-year license period. The original provision for severance damages as provided in the first House bill was restored by the conferees. Some are of the opinion that the definition of "navigable waters" as given in the conference report will make it impossible for any one to build a dam for any purpose in any creek or small stream which empties into a navigable river without first obtaining a license from the Federal Power Commission.

The Sundry Civil Bill For 1921

At present the Sundry Civil Bill, introduced on the floor of the House on January 29, is undergoing discussion in that body. This bill carries many items of interest to engineers, those dealing with the investigation of the Boston-Washington super-power project and an increased appropriation providing for early completion of the topographic map of the United States, being of special importance.

It will be recalled that Engineering Council took a particularly active part in urging an appropriation for the power investigation so that that work could go forward at once. The Council's committee composed of William S. Murray, Prof. D. C. Jackson, Prof. L. P. Breckenridge and M. O. Leighton, appeared before the House Committee on Appropriations in behalf of this measure. Mr. Leighton also appeared for Engineering Council in behalf of the increased topographic mapping appropriation. Both of these matters have come up for consideration on the House floor and have remained in the bill, although there has been some opposition to the power investigation in the House discussion. The former appropriates $125,000 to the Geological Survey to carry on the investigation. The mapping appropriation carries $330,000 as compared with $325,000 for last year. In addition to the latter amount, $100,000 will be available from the Army for topographic mapping work.

Other items of interest to engineers that have remained in the Sundry Civil Bill after House discussion are: California Debris Commission, $15,000; enforcement of anti-trust laws, $150,000; new mining experiment stations, $175,000; petroleum and natural gas investigations, $135,000 (in all for the Bureau of Mines, $1,277,642); Bureau of Standards, $87,272; Reclamation Service, $7,898,000; mineral resources work in Geological Survey $125,000 (in all for the Geological Survey $1,655,700); Emergency Shipping Board, $70,000,000; maintenance of Panama Canal, $9,281,851; National Advisory Committee for Aeronautics, $200,000; flood control on Mississippi, $6,670,000; and prevention of obstructions and deposits in New York harbor $109,260.

[1] Engineering Council is an organization of national technical societies created to consider matters of common concern to engineers as well as those of public welfare in which the profession is interested. The headquarters of Engineering Council are located in the Engineering Societies Building, 29 West 39th Street, New York City. The Council also maintains a Washington office with M. O. Leighton, chairman of the National Service Department, in charge. This office is in the McLachlen Building, 10th and G Streets, Washington, D. C. The officers of Engineering Council are: J. Parke Channing, *Chairman*; Alfred D. Flinn, *Secretary*.

Ordnance Department Establishes New Engineering Staff

The Ordnance Department has established a staff of highly trained engineers under the direction of General C. L'H. Ruggles as chief of Technical Staff, whose function it shall be to study all of the technical problems of the Ordnance Department which seem worthy of development.

Through the National Service Department of Engineering Council, General Ruggles has requested that engineering societies throughout the country consider the following problems the solution of which will be beneficial to both the Ordnance Department and to many manufacturing industries:

Machinability of Metals. This question directly affects the production and output of a shop. Much time can be lost due to indiscriminately mixing articles of different machinability which are to go through the same machine operations. Maximum production can only be secured through the control of the character of the metal sent through the machine shop.

A test to determine machinability and thereby regulate the distribution of parts to be machined should be developed into a simple practical shop test. This test should result in separating materials of different machinability into different groups and each group could then be sent to the machines best adjusted to handle it.

Nomenclature of Metals. The methods of nomenclature of metals vary from shop to shop, from industry to industry, from society to society, and from country to country. The British Institute of Metals has been at work on the problem for a number of years. Several engineering societies in America have made individual attempts to solve the problem. The Bureau of Standards has a system of its own for designating metals. To date nothing good enough has been developed to support either as an international or a national standard.

It is believed that by proper correlated and concerted effort a simple comprehensive system can be evolved which will be broad and expansive enough to allow all non-ferrous alloys and metals to come within its scope. It is further believed that by similar methods a system can be evolved for ferrous metals.

Suggestions for the solution of these problems will be welcomed by the Secretary.

A New Road Bill

The Senate Committee on Post Office and Post Roads began hearings on the Townsend Road bill on May 4. This bill proposes to create a Federal Highway Commission having charge of all Federal road work. The hearings will attempt to develop whether or not Congress should discontinue its present system of Federal aid to roads, or whether to appropriate larger sums for use after 1921, and whether it is to make a change in all its road policies.

So far the hearings have not developed sentiment in favor of stimulation of road construction at this time, due to the great need for labor on farms and in the industries. Some of the witnesses have argued that this is a good time to formulate definite and more coherent road-building policies. Practically every witness has favored the construction of special highways to be built and maintained by the Federal Government.

From the engineers' standpoint, the purpose of the Townsend Bill is most commendable, but it is pointed out that the plan for a National Department of Public Works contemplates that the Bureau of Roads will be included in the Public Works Department, which means that the formation of road policies and the administration of those policies will come under suitably qualified direction that will not only accomplish all that the Townsend Bill proposes, but at the same time will coördinate this work with the other similar functions of the Government without creating another separate commission.

NEWS OF THE ENGINEERING SOCIETIES

Meetings of the Engineering Section of National Safety Council, Taylor Society, American Gear Manufacturers' Association, National Metal Trades Association and the Western Society of Engineers

Standardization of Industrial Safeguards

The first conference of the Engineering Section of the National Safety Council was held in New York on April 27. David S. Beyer, vice-president and chief engineer of the Liberty Mutual Insurance Co., and one of the founders of the Engineering Section, explained the activities which this new section of the National Safety Council will undertake. About ten years ago the states began to pass laws on safety in industry which naturally were very general and which were left in most cases to the interpretation of inspectors. Later on efforts were made to formulate adequate and reasonable standards, but even these were not always perfect and were more or less in conflict with one another, and with the requirements of insurance companies. It is with a view to harmonizing the conflicting points of view of the engineers, the insurance companies and officials in industry that the Engineering Section of the National Safety Council has been formed. The work will be undertaken under the general control of the American Engineering Standards Committee, and the Engineering Section will engage in the active codification of industrial safeguarding.

Taylor Society

A meeting of the Taylor Society was held at Rochester on May 6, 7, and 8, under the auspices of the industrial management council and the manufacturers' council of the Rochester Chamber of Commerce.

One of the professional papers, Promulgation of Standards by the Taylor Society, by William O. Lichtner, contained an interesting suggestion in regard to enlarging the field of activities of the society. It proposed to standardize the terminology involved in the operation of the Taylor system, to define clearly the functions and executive titles of a standard oragnization, to prescribe definite policies on bonus payments, base rates and total earnings, and to compile a list of reference books on industrial management. As a preliminary step in this direction and with a view to stimulate discussion, Mr. Lichtner submitted a list of standard definitions of such terms as apportioning stores, available future board ticket, base rate, day work, employee's time sheet, idle machine ticket, job, etc., and a bibliography on industrial management containing over 100 references. He also outlined some general principles as a basis upon which a definite policy of remunerating employees could be constructed. These principles refer to the adoption of a standard time for all major operations and setting a base rate for each operator.

Honorary membership was conferred on Carl G. Barth, of Buffalo, N. Y., who is the third person thus honored by the society. The other two honorary memberships were conferred on the late Frederick W. Taylor and Henri Le Chatelier.

American Gear Manufacturers' Association

Important committee reports on standardization work were presented at the fourth annual meeting of the American Gear Manufacturers' Association, held in Detroit from April 29 to May 1. The report of the general standardization committee called the attention of the Association to the American Engineering Standards Committee organized as a clearing house for the standardization work of this character. It referred to the acceptance by the association of joint sponsorship with The American Society of Mechanical Engineers for the standardization of gears of all kinds under the American Engineering Standards Committee. A sectional committee is to be formed by these organizations to formulate gear standards which, if found to meet requirements, will in time be known as the American standard.

The bevel and spiral gear committee submitted for the consideration of the members a table giving the maximum addendum for bevel gears based on a back cone radius of 1 in. and covering $14\frac{1}{2}$-deg. and 20-deg. obliquity, with ratios of from 1 to 1 up to 1 to 8.

The report of the sprocket committee contained tables of dimensions for roller-chain sprockets, relative position of wheels, speeds, and approximate speed ratios and sprocket diameters for single-width roller chain wheel with chain of different pitches. The standardization of herringbone gears and of worm gears was discussed in connection with the preliminary work in those directions contained in the reports of the respective committees.

The hardening and heat-treating committee submitted a list of 15 kinds of forged and rolled steel suitable to the gear industry. The first steel was a basic open-hearth or bessemer steel which was suggested as a good steel for a cheap class of work, being somewhat superior to screw-machine stock and possessing good machine, heat-treating and case-hardening qualities. The percentage analysis of this steel is: Carbon, 0.15 to 0.25; silicon, maximum, 0.25; manganese, 0.60 to 0.90; sulphur, 0.06 to 0.09; and phosphorus, maximum, 0.06. A number of the other steels listed conformed to the specifications of the Society of Automotive Engineers, and some had slightly different specifications. The suggestion was made in the discussion of this report that the Society of Automotive Engineers' specifications be followed as closely as possible to avoid confusion.

The Hump Method of Steel Treating was the subject of an address by G. W. Tall, Leeds and Northrup Co., Philadelphia. Mr. Tall stated that the cost of using the Hump process was $1\frac{1}{2}$ to 2 cents per pound for hardening and 2 cents for drawing, or about the same as with the use of oil or lead pots. During the discussion, Mr. Peterson, Packard Motor Car Co., asserted that steel treated by the Hump process shows an elastic limit of 222,000 lb. per sq. in. as compared with 201,000 lb. per sq. in. when pieces are treated in a lead pot.

Other professional papers were Gears from the Purchasers' Standpoint, by D. G. Stanbrough, Packard Motor Car Company, and Routing of Gears and Machine Parts Through the Factory, by J. A. Urquhart, Brown & Sharpe Manufacturing Company.

National Metal Trades Association

The need for increased production in industry was emphasized at the twenty-second annual convention of the National Metal Trades Association, held in New York on April 21 and 22. President J. W. O'Leary insisted that systems of payments based on production are "the only corrective of the prevailing fallacious idea that wages ought to be based on the cost of living." He said that careful studies of the consumption requirements of the market open to industry both in the United States and the world were necessary before it could be properly determined whether the work day could be shortened or must be lengthened.

With the aid of numerous charts, M. W. Alexander, general manager of the National Industrial Conference Board, Boston, compared the advance in wages to the high cost of living. The National Industrial Conference Board, he asserted, had found from authentic sources that to March 1920 the average cost of living had increased 95 per cent from the July 1914 level. In that time clothing showed the greatest advance and was still tending upward. He demonstrated, however, that the high cost of

living has lagged behind the cost of wages in leading industries. A chart giving a comparison of changes in hourly and weekly earnings with changes in the cost of living, taking the condition in 1914 at 100 points as a basis, showed that hourly earnings in the metal-manufacturing industry increased from 100 to 216 points, weekly earnings from 100 to 233 points, and the cost of liivng from 100 to 195 points. Another chart giving a comparison of index numbers of changes in average weekly earnings of male workers in different industries with those applying to the cost of living, showed that earnings in the metal trade rose from 100 to 223 points, in the cotton industry from 100 to 244 points, in the wool industry from 100 to 254 points, in the silk industry from 100 to 216 points, in the boot and shoe industry from 100 to 212 points, while in the cost of living it rose from 100 to 195 points.

Dr. Richard H. Waldo, of the Inter-Racial Council, New York, asserted that there is today in the United States a shortage of labor amounting to more than 5,000,000 workers. He further said that the policy of the American Federation of Labor to keep the supply of labor down to the smallest possible amount would ultimately result in workers being detained in foreign countries to manufacture goods for the United States. He urged that the National Metal Trades Association exert its efforts in connection with securing the adoption by the United States of a well-considered policy of immigration.

There was a general discussion of the question of shop representation with arguments both in favor of and against such representation. In each instance the arguments set forward were warmly approved, a circumstance which clearly indicated that the question is still an open one among the members. That such is the case was admitted by President O'Leary, who observed that the question was too broad to be settled easily and expected that it would be discussed again at the next convention.—Abstracted from report in *Iron Age,* April 29.

Western Society of Engineers Entertains Boards of Civil, Mining, Mechanical and Electrical Engineers

IT is evident to those who have kept in touch with the work of the engineering organizations that the last two years have witnessed profound changes in the relationship of the societies to each other. Coöperation between all the societies there has always been, but this recent period has seen the birth of a real movement for society unity, the embryo of which has already taken shape and is sufficiently fashioned to enable its advocates to "show it in public" in Washington at the Organizing Conference to be held there June 3 and 4.

Sympathetic with this movement for society unity, the Western Society of Engineers invited the governing boards of the four national engineering societies to be its guests in the western metropolis on April 19 and 20, and incidentally, as the account of the meeting will show, provided the psychological opportunity for securing the unity of at least these four societies in the plans for the Organizing Conference.

Three of the boards—the A. S. C. E., A. I. M. E. and the A. S. M. E.—were able to hold regular meetings and transact their usual business while in Chicago. The Electricals had just had their regular meeting in Boston, but members of their board, headed by their President, Mr. Calvert Townley, attended informally.

The meeting of the A. S. M. E. Council was held on Monday morning, and was the regular April meeting. An account of it is given elsewhere under the usual heading of Council Notes.

On the evening of the 19th, the members of the boards were the guests of the Western Society at a banquet at the Hotel La Salle. A. Stuart Baldwin, Past-President of the W. S. E., presided, and introduced the guests of the evening. The officers of the national societies and of the Western Society occupied seats on the platform.

Arthur P. Davis, president of the A. S. C. E., Arthur Fletcher, director of the A. I. M. E., representing Herbert Hoover, president, Fred J. Miller, president of the A. S. M. E., and Calvert Townley, president of the A. I. E. E., were each introduced in turn and made appropriate addresses on engineering organization, emphasizing the main purpose of such organization as development of the engineer for service to the public.

President Fred J. Miller spoke particularly of the public work of the proposed engineering federation, expressing his opinion that engineers should speak as expert witnesses only, and should not forget that the laymen have as much right to their opinion as the engineers in matters of public policy. He spoke also of the need for engineering publicity, developed by the societies appointing staff members to collaborate with editors of the daily press in translating what the engineer is doing into terms the public could understand. His address appears on page 336.

Mr. Townley voiced as the essential problem the development of team work among engineers, to the end of unselfish public service, the ideal of professional organization.

Mr. Davis stated that the great changes which have come into men's minds in the past five years must be reflected in an expansion and recasting of the engineering organizations to keep abreast of them.

Mr. Fletcher laid stress on the engineer's fitness for solving present-day problems, as exemplified in the service rendered to the public by Mr. Hoover.

The meeting was concluded by a masterly address by Dr. Theodore G. Soares, head of the Department of Theology, University of Chicago, who declaimed the traditional modesty of engineers. He held that the engineer must be more than an expert witness. He must prescribe, and order, and see that his orders are carried out. Engineering has a first place in modern life, and grave responsibilities now rest on the engineer.

On the Tuesday the program continued with a luncheon at the University Club, at which were present members of the board of W. S. E., members of the boards of the four national societies, Chicago representatives on Engineering Council and also the Chicago Committees of the local sections of the national societies. Mr. Townley presided at this meeting until he had to leave to catch a train, when his place was taken by Mr. Miller.

E. S. Nethercut, Secretary of the W. S. E., opened with a lucid description of the origin and growth of his society. He enumerated the present extensive committee activities of the organization, in which the field of public service was in no way neglected. He discussed the relation between the local society and the section of the national societies, by means of which effective coöperation had been secured and mutual development consummated.

E. S. Carman, member of the Joint Conference Committee of the National Societies, and Chairman of the Local Sections Committee of the A. S. M. E., was called upon by the presiding officer to describe the plan of society federation proposed in the report of the Joint Conference Committee. Mr. Carman traced the history of coöperative movements, and indicated how many of those in the societies felt that the time for the final step in organization had now come.

During the two days at Chicago, the Civil Engineers were concerned with reconciling the vote of their membership upon so-called "Question 3" with the desire of the Board to participate in the Washington Conference, and they invited into session the members of the boards of the other societies. The Board eventually evolved a plan enabling the Society to participate in the Organizing Conference in Washington, June 3 and 4.

The President of the Western Society, Frederick D. Copeland, was unavoidably absent, as was also Arthur L. Rice, Chairman of the A.S.M.E. Chicago Section, who was performing railroad strike duty as a member of the Home Guard.

LIBRARY NOTES AND BOOK REVIEWS

AIRCRAFT YEAR BOOK. Issued by Manufacturers' Aircraft Association, Inc. Published by Doubleday, Page & Co., New York, 1920. Cloth, 6 x 9 in., 333 pp., illus., $2.

The first issue of this annual review of the industry appeared in 1919. The present issue reviews the progress up to date in various fields of aeronautical activity. Aircraft in commerce and in warfare, technical developments between 1914 and 1919, and cross-country flying are discussed and a detailed story of the recent achievements of the firms composing the Association is given. The book also contains the text of the convention relating to international air navigation, the report of the American Aviation Commission, a chronology of the events of 1919 and appendices giving information on governmental activities.

COURS DE MÉCANIQUE RATIONNELLE avec de Nombreuses Applications a l'Usage des Ingénieurs-Cinématique-Statique-Dynamique. By L. Legrand. Ch. Béranger, Paris and Liége 1920. Cloth, 6 x 10 in., 618 pp., illus., 48 francs.

The author of this textbook believes that there is need for a work which will present the subject in strictly scientific manner, but which will draw its illustrations from the realm of industrial mechanics, rather than from celestial mechanics, as is usually done in theoretical treatises, and offers the present book for this purpose. He has attempted to supply a complete course in which an engineer will find the theory illustrated by problems which arise in the practice of applied mechanics in various industries.

EFFICIENT BOILER MANAGEMENT. With notes on the operation of reheating furnaces. By Charles F. Wade. Longmans, Green & Co., New York, 1919. Cloth, 6 x 9 in., 280 pp., illus., tables, $4.50.

The author of this work endeavors to explain, in their proper sequence, the elementary scientific principles underlying the various subjects combined in boiler management and the systematic practical application of these principles to obtain the greatest efficiency. The book is intended to fill the gap between the treatises upon the chemistry of combustion, etc., in which practical applications are omitted, and the practical textbooks on boiler plants, which give little attention to the fundamental principles governing their operation.

ELEMENTS OF STEAM AND GAS POWER ENGINEERING. By Andrey A. Potter and James P. Calderwood. First edition. McGraw-Hill Book Co., Inc., New York, 1920. Cloth, 5 x 8 in., 297 pp., illus., $2.50.

The object of this treatise is to provide a clear, concrete statement of the principles underlying the construction and operation of steam and gas-power equipment. It is intended for the use of students of engineering with power-plant equipment before they take up the study of thermodynamics and design, and for those responsible for the operation of power plants.

HOW TO MAKE AND USE GRAPHIC CHARTS. By Allan C. Haskell with an introduction by Richard T. Dana. First edition. Codex Book Co., Inc., New York, 1919. Cloth, 6 x 9 in., 540 pp., diagrams, $5.

The object of this book is to call attention to the many functions which graphic methods can accomplish and to indicate the suitability of the different methods of charting for various purposes. After describing the theory and construction of the types of charts, the author gives many examples of those used to aid in organization and management, in analyzing costs and operating characteristics, in recording tests, in predicting trends and tendencies, in computing, designing and estimating. Bibliographies are given with most of the chapters.

MENSURATION FOR MARINE AND MECHANICAL ENGINEERS. (Second and First Class Board of Trade Examinations). By John W. Angles. Longmans, Green & Co., New York, 1919. Cloth, 5 x 7 in., 162 pp., illus., diagrams, $1.75.

This textbook is intended to enable students to pass the examinations of the Board of Trade (Great Britain) for licenses as marine engineers, but will be useful, the author hopes, to engineering students in other lines. A feature is made of fully solved examples, illustrating the practical applications of the theoretical principles involved in the text.

OPPORTUNITIES IN ENGINEERING. By Charles M. Horton. Harper & Brothers, New York. Paper, 5 x 8 in., 90 pp., $1.

The tremendous power which engineers wield in world affairs has inspired the author to set forth in this book the opportunities for constructive work which lie before the man who selects engineering as his profession. He also describes the type which, being best fitted for the work, is most likely to succeed and gives some hints for the guidance of the student who is choosing his vocation, as well as some examples of what has been done by those already in the work.

ORGANIZING FOR WORK. By H. L. Gantt. Harcourt, Brace & Howe, Inc., New York, 1919. Cloth, 7 x 5 in., 113 pp., $1.25.

Our civilization depends, according to Mr. Gantt, upon the effectiveness with which our combined industrial and business system works, and recent revolutionary attempts to overthrow it are due to the failure of the present system to recognize fully its responsibility to the community. The author believes that there must be a return to the principle that the first aim of business is to render service to the community and that this result can be peacefully obtained by the use of familiar methods, whose use for the purpose he discusses in the present book.

SAFETY FUNDAMENTALS. Lectures given by Safety Institute of America (Maintaining the American Museum of Safety). Safety Institute of America, New York, 1920. Cloth, 5 x 8 in., 228 pp., illus., plates, $2.

Contents: The body which gets hurt.—The injured body and its treatment; (*a*) Protective clothing for men; (*b*) Suitable work garments for women in industry.—Safe heads and good eyes.—Guarding machinery.—Arrangement of machinery and working places.—Heating and ventilation.—Illumination.—Nature's forces for and against workmen.—Safety education and shop organization.

These lectures were delivered during 1919 before an audience of factory inspectors employed by the City of New York, the States of New York and New Jersey, and insurance companies in and near New York. They are intended to enlarge the knowledge and increase the experience of inspectors with respect to the various fundamentals that affect the mind and body of the workmen.

THE STORY OF ELECTRICITY. Vol. 1. Edited by T. Commerford Martin and Stephen Leidy Coles. The Story of Electricity Company, M. M. Marcy, New York, 1919. Cloth, 11 x 8 in., 661 pp., $25 for vol. 1 and 2.

The authors of this volume have prepared an account in popular language of the development of the electrical industry, with particular reference to American achievement. After an introductory chapter on the beginnings of electrical science, the invention and growth of the telegraph, telephone, central station, electric railway, etc., are described. Chapters are devoted to the great electrical companies. The various chapters are accompanied by biographical sketches and portraits of engineers of prominence, past and present. Numerous well-selected illustrations add to the value of the work.

TECHNO-CHEMICAL RECEIPT BOOK. Containing Several Thousand Receipts and Processes, Covering the Latest, Most Important and Most Useful Discoveries in Chemical Technology and Their Practical Application in the Arts and the Industries. Compiled and edited by William T. Brannt and William H. Wahl. New enlarged edition. Henry Carey Baird and Co., Inc., New York, 1919. Cloth, 5 x 8 in., 516 pp., illus., tables, $2.50.

The principal aim in preparing this work has been to give a compendious collection of approved receipts and processes of practical applications in the industries. The receipts have been principally derived from German sources and most of them have been tested practically. The present edition has been revised and various receipts added.